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(54) **Electronic tuning antenna system.**

(57) At the feed side (22, 22') of each antenna element (15,15') comprising transmitting conductor ways formed in turnback shape in continuation and having distributed constant impedance are electrically connected variable tuning units (16,18) including an impedance adjusting element (23) and voltage variable capacitors (17,17').

Antenna feed terminals (22, 22') are connected through a coaxial cable to input terminals at a remoteset radio receiver. A tuning control signal generated within the radio receiver is fed to the voltage variable capacitors (17, 17') at the antenna circuit through the coaxial cable. The tuning control signal allows the antenna circuit to resonate at a particular frequency within a frequency band, the frequency being variable in response to the control signal. The antenna element, having distributed constant inductance, functions to have the best antenna radiation efficiency at the resonant frequency by means of the variable tuning unit and is considerably smaller than a conventional dipole.

At the resonant frequency, the characteristic impedance at the feed terminals to the antenna circuit becomes equal to that at the receiving input terminals connected to the antenna circuit, so as to increase efficiency of transfer of the signal from the antenna to the radio receiver.

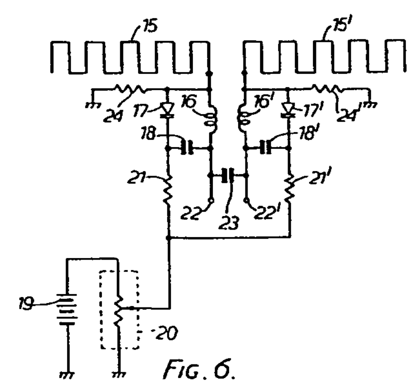

FIG. 6.

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ELECTRONIC TUNING ANTENNA SYSTEM

The present invention relates to an electronic tuning antenna system which may be used for receiving television signals in the VHF and UHF bands, FM radio signals, or any other communications signals.

At present, a widely used and efficient antenna element is a dipole antenna having a length equal to half of the wave length of the signal being received or transmitted. However, a half-wave length dipole antenna for a frequency band in the VHF band is very large in size from the viewpoint of practical use.

Such a large-sized antenna is difficult to set and has many problems of maintenance and safety. Therefore, from the viewpoint of facilitating setting the antenna, it is desirable to make the antenna as amall as possible.

Hitherto, it has been tried or proposed in other fields to make a small-sized dipole antenna, in which antenna gain has been very low in comparison with the half wave-length dipole antenna.

The reason for this is that a loading means is required to contract the dipole antenna in length, and this loading means causes a loss of radiation power as a result of the resistance loss which exists in a small-sized dipole antenna, thereby considerably reducing the radiation power and resulting in low radiation efficiency.

Lowering of the radiation efficiency, of course, means lowering of the antenna gain.

Furthermore, even with the aforesaid half-wave length dipole antenna, set values of V.S.W.R. at the feed terminals of the antenna cannot be ideal at all frequency points within the corresponding frequency band, which is due to the fact that the half-wave length dipole antenna of fixed length has only one perfect frequency resonance condition, the values of V.S.W.R. being of course deteriorated at other frequencies. The defect causes mismatching in characteristic impedance between the half-wave dipole antenna and any radio receiver connected thereto. A reflection loss exists in reception signal energy transmission due to the mismatching, thereby lowering the gain of the complete antenna system including the antenna and radio receiver.

From the above, it may be seen that a small-sized antenna is required which has a high gain and ideal values of V.S.W.R. in the characteristic impedance at the feed terminals at all frequency points within a corresponding frequency band.

The present invention provides an electronic tuning antenna system, characterised in that there are provided:

a pair of antenna elements which are adapted to have distributed constant inductance by being in the form of conductors bent at desired points;

an antenna circuit comprising variable reactance circuits connected to each of said elements, said variable reactance circuits including variable capacity diodes and an impedance adjusting reactance element interconnected between feed terminals of said pair of antenna elements; and

a communications apparatus arranged to be connected via a coaxial cable to said antenna circuit whereby

electrical signals associated with the conversion between electromagnetic radiation and electrical signals at said antenna elements pass through said coaxial cable, said communications apparatus including a control circuit for providing control signals fed to said antenna circuit and arranged to generate controllable bias voltages on said variable capacity diodes, thereby to tune said antenna system.

The invention may be equally well applied to antenna systems for transmitting or receiving signals. In the former case, the communications apparatus will be a transmitter, and in the latter case, it will be a receiver. The embodiments described hereafter will, for the sake of convenience, be described with reference to a radio receiver.

Embodiments of the invention provide an antenna system which has antenna elements of reduced size, improves the gain of the antenna, controls electronically the tuning of the antenna with the radio receiver connected thereto, and connects the antenna and radio receiver so that matching of the characteristic impedance therebetween is always ideal, thereby eliminating loss in the receiving signal energy transmission between the antenna and the receiver as much as possible, so as to obtain a high gain.

An embodiment of the antenna system of the invention is a receiving antenna system for receiving FM radio including a remote-set radio receiver. The antenna system is of a turn-back shape comprising continuous transmission conductor ways, and has at the feed side of the antenna elements, which have distributed constant inductance, a variable tuning unit including a voltage variable reactance and an impedance adjusting reactance element, so that they are electrically connected to form an antenna circuit. A voltage variable capacitor, which may be a variable capacity diode, is connected within the voltage variable

reactance. The antenna feed terminals are connected with the input terminals of the remote-set radio receiver through a coaxial cable. A tuning control signal generated within the radio receiver is fed through the coaxial cable to a voltage variable reactance element within the voltage variable reactance circuit of the antenna circuit, the antenna circuit being resonant by means of the tuning control signal with the particular variable frequency previously set within the frequency band. The antenna elements having distributed constant inductance are combined with the variable tuning unit to function to have the best antenna radiation efficiency. For a signal at the resonant frequency, the characteristic impedance at the feed terminals to the antenna circuit is equal to that at the receiving input terminals of the radio receiver connected to the antenna circuit, so that a RF signal of selected resonance is fed to the radio receiver most effectively through the coaxial cable.

It is therefore possible to provide a relatively small antenna having high gain by use of the distributed constant loading elements combined with the tuning unit, and it is possible to provide an antenna system of high gain due to the fact that ideal matching of the characteristic impedances of the antenna and radio receiver is realized to enable a reduction in transmission loss of the received signal.

An antenna system of another developed form of the invention utilises a frequency signal, divided from the oscillation frequency signal generated at the local oscillator within the radio receiver, as the control signal used for tuning gang control of both the antenna and radio receiver, the divided frequency signal being fed to the antenna through the coaxial cable and converted into a tuning control d.c. voltage through

a frequency to d.c. voltage converter, thereby providing the tuning control voltage, and making it possible to obtain more complete tuning control in association.

In order that the present invention may be more readily understood, embodiments thereof will now be described, by way of example, with reference to the accompanying drawings, in which:

Figures 1a and 1b show schematically a conventional contraction type antenna;

Figure 2 shows an example of antenna element used for the antenna system of the invention;

Figure 3 shows the construction of an embodiment of the antenna system of the invention;

Figure 4 is a view of the characteristic curve of reactance to frequency of a parallel resonance circuit for tuning control of the system shown in Figure 4;

Figure 5 is a view of the characteristic curve of impedance of each antenna of the system shown in Figure 4;

Figure 6 shows a modified embodiment of the antenna system of the invention;

Figures 7 to 14 are views of various other examples of antenna element used for the antenna system of the invention;

Figures 15 and 16 are views of another modified embodiment of antenna system;

Figure 17a shows a further modified example of the antenna element whicy may be used for the antenna system of the invention;

Figure 17b is an enlarged view of the principal portion of the element shown in Figure 17a;

Figures 18 to 21 are views of still further examples of antenna elements;

Figure 22 shows still another antenna element;

Figure 23a is an enlarged view of the principal portion of the element shown in Figure 22;

Figure 23b is a sectional view of the principal portion shown in Figure 23a;

Figures 24 to 26 show yet further examples of antenna elements in which a is a developed view of each antenna element, and b, c are sectional views thereof;

Figures 27 to 29 show yet further examples of antenna elements in which a is a perspective view thereof and b is a sectional view of the same;

Figure 30 is a circuit diagram of still another modified embodiment of the invention;

Figure 31 is a circuit diagram of yet another modified embodiment of the invention;

Figure 32 is a circuit diagram of a further modified embodiment of the invention;

Figure 33 shows a still further modified embodiment of the antenna system of the invention;

Figure 34 shows a yet further embodiment of the antenna system of the invention;

Figure 35 is a block diagram of an embodiment of a receiving device of the invention;

Figure 36 is a circuit diagram of a particular construction of an antenna portion;

Figures 37 and 38 are illustrations of the operational principle of the system;

Figure 39 is a block diagram of another embodiment of the receiving device of the invention;

Figure 40 shows an embodiment of a phase difference feeding type antenna system;

Figure 41 is a view of the directional characteristic curve of the antenna system shown in Figure 40;

Figure 42 is a view of the characteristic curve of the frequency-gain of the antenna system shown in Figure 40;

Figures 43 and 43a are views showing two modified embodiments of the phase difference feeding type antenna system;

Figure 44 is a view directional characteristic curve of the antenna system shown in Figure 43;

Figure 45 is a view of the electric field directional characteristic curve of the antenna system shown in Figure 43; and

Figures 46 and 47 are views showing a yet further modified embodiment of the invention.

When an antenna is small-sized relative to the wave length of the signal in use, radiation resistance considerably decreases relative to radiation reactance. Hence, radiation efficiency lowers to reduce the working gain of the antenna. Therefore, it is difficult to materialize a small-sized antenna, which does not lower the radiation efficiency and, even with an element length nearly as small as a conventional small-sized antenna, is high in working gain. Conventionally, a loading antenna has been proposed to put the small-sized antenna in practice. A conventional contraction type dipole antenna is exemplified in Figures 1a and b.

In Figure 1a, the dipole antenna has contracted elements 1, 1' in combination with coils 2, 2' having reactance components negativing the reactance components of the elements 1,1' so that the impedance at the feed terminals 3, 3' becomes a desired value at the desired frequency. In Figure 1b, coils 6 and 6' are added between contracted elements 4 and 5 and between elements 4' and 5' thereby negativing the reactance components of these elements so that the impedance at the feed terminals 7, 7' becomes a desired resistance value at the desired frequency. These antenna devices, however, require very large reactances to be added to the contracted elements, whereby the loss introduced by each coil lowers the radiation efficiency to reduce the working gain of the antenna, thereby not being practicable.

Referring to Figure 2, a typical construction of

an antenna element used in this invention is shown, in which contracted elements 8 and 8' (hereinafter referred to merely as elements 8, 8') having distributed constant inductance comprise metallic foil or wire, such as copper, aluminium or iron, of low electric resistance value, or conductive foil on a printed base and are bent at desired points, a desired number of times, in each direction, and at each angle to thereby be formed as shown. The elements 8,8'

are subjected to distributed constant impedance caused by bending the conductors and by continuously arranging the conductors at the bending points and between each bending point in relation of being distributed mutually lengthwise of and perpendicularly to each element, thereby being equivalent to the conventional elements, as shown in Figs. 1-a and -b, added with the coil for negativing reactance of the element. Hence, use of such elements 8, 8' requires no concentrated constant coils used conventionally. Furthermore, since the conductors constituting the elements 8, 8' are usable of material of foil-like or tube-like shape of wide surface area, whereby a loss is extremely reducible. Hence, it is possible to solve the problem in that the loss by coil hitherto is very large to thereby lower the radiation efficiency, to improve the working gain, and to realize an antenna practicable enough even when small-sized.

Fig. 3 shows a modified embodiment of the antenna device of the invention. Since the embodiment in Fig. 2 can adopt tuning (matching) only in a limited range of frequency, variable reactance circuits are interconnected with the elements circuits. A parallel resonance or series resonance circuit is usable as the variable reactance circuit. For example, when using the parallel resonance circuit, its reactance, as shown in Fig. 4,

becomes a large plus and minus value before or after the resonance frequency fr, whereby fr is properly set to enable control of reactance component of the element. An element pattern is so designed that impedance at frequencies f_1 - f_2 - f_3 of units 10, 10' of the elements in Fig. 3, to the elements, are connected parallel resonance circuits each comprising a coil 11 and variable condenser 12 and a coil 11' and variable condenser 12', and resonance frequency is set to a desired value so that the reactance becomes plus at the frequencies f_1 - f_2 - f_3, whereby the impedance turns in a curve B as shown in Fig. 5. Furthermore, when a condenser 14 is interposed between feed terminals 13 and 13', impedance describes a curve C in Fig. 5, thus obtaining tuning at frequency f_2. It is enough to satisfy tuning condition within the whole zone of frequencies f_1 - f_2 - f_3 by changing values of variable condensers 12 12' to changing the resonance frequency and by changing the reactance component added to the elements 10, 10'.

The embodiment in Fig. 3 employs the parallel resonance circuit. Alternatively, the series resonance circuit is used to provide a required reactance value to thereby, of course, obtain the same tuning as the above. Also, a value of condenser may of course be fixed to change an inductance value of the coil.

Fig. 6 shows another embodiment of the invention, in

which parallel resonance circuits each comprising a coil 16, barrier capacitor 17 and condenser 18 and a coil 16', barrier capacitor 17' and condenser 18' are connected with respect to elements 15, 15' respectively so that bias voltage of barrier capacitors 17, 17' becomes voltage variably divided by a potentiometer 20 from voltage of d.c. source 19 and supplied through high-frequency blocking resistances 21, 21'. If a condenser 23 is provided between the feed terminals 22 and 22', tuning is obtainable as the same as the embodiment in Fig. 3 and remote tuning control is possible. In addition, in Fig. 6, reference numerals 24, 24' designate high resistances for feeding bias voltage to barrier capacitors 17, 17'.

As seen from the above, this invention makes it possible to constitute the antenna, which is tunable in very small length in comparison with wave length of frequency in use and at individual frequency with respect to the whole zone in a range of desired frequency, of elements having negative reactance small enough and a very small loss, and of positive reactance control circuits small enough to offset the above negative reactance component small enough, that is, positive reactance control circuits of a fully small loss.

In other words, a super-small-sized, lightweight, and plane antenna of high working gain becomes realizable to

thereby facilitate installation of the antenna and increase in freeness when installed. The antenna elements can be produced by etching a printed base or punching metallic foils and easy and inexpensive to manufacture. In a case of using the printed base, especially, patterns of element and circuitry can be formed simultaneously on the same base, thereby enabling integral construction to be advantageous in reduction of the number of processes and improvement in reliability. Also, the element has narrow-band characteristic not to tune to signal other than tuning-desired signal and has interference signal eliminating capability, thereby presenting good receiving performance with respect to a connected receiver.

The aforesaid embodiments have pairs of antenna elements 10, 10' and 15, 15' which are formed of turn-back shaped and continuous transmitting conductor ways and have distributed constant impedance, the elements being perpendicular and parallel to the longitudinal direction of the element and bent at right angles at a desired number of points on the same plane, in brief, antenna elements 8, 8' are each formed in a rectangular wave form. Alternatively, antenna elements 26, 26', as shown in Fig. 7, may of course be used, which have feed terminals 25, 25' and comprise transmitting conductor ways of sine-wave-like turn-back shape. The pairs of antenna elements 10, 10'

and 15, 15', as shown in Fig. 8, are used as; antenna elements 28, 28' having feed terminals 27, 27' and of double construction in plane; antenna elements 30, 30', as shown in Fig. 9, having feed terminals 29, 29' and of spirally twisted construction; antenna elements 32, 32', as shown in Fig. 10, having feed terminals 31, 31' and of construction in circular arc; or antenna elements 34, 34', as shown in Fig. 11, having feed terminals 33, 33' and of construction of inverted V-like shape. The pair of elements 8, 8' are connected at free ends reverse to feed terminals 9, 9' through; a symmetrical transmitting conductor way as shown in Fig. 12; a symmetrical transmitting conductor route 36 of rectangular wave-form in plane as shown in Fig. 13; or a symmetrical transmitting conductor route 37 of rectangular wave-form in a three-dimensional manner as shown in Fig. 14, thereby being usable as a turn-back dipole antenna. In the above embodiments, the variable reactance circuit is connected to the feeding sides of antenna elements. Alternatively, the variable reactance circuit may of course be insertably connected to the antenna elements 10, 10' and 15, 15' as shown in Figs. 15 and 16.

Figs. 17-a and -b show a further example of antenna element, in which contracted elements 25 and 25' (hereinafter referred merely to elements 25, 25') employ metallic

foil or wire, such as copper, aluminum or iron, of low electric resistance, or conductive foil on a printed base. The elements 25, 25' are bent at the required points, in the respective directions and at angles, and in the required number of times. The elements 25, 25' are subjected to distributed constant inductance caused by the arrangement in continuation of the conductors which are distributed alternately lengthwise of and perpendicular to the elements at the bending points and between each bending point. Hence, the elements 25, 25' are equivalent to the elements in the conventional example showing in Figs. 1-a and -b, the conventional elements being added with coils for eliminating their reactance, whereby use of the elements 25, 25' requires no concentrated constant coil in conventional use. The conductors, which constituting the elements 25, 25', are usable of material of foil-like shape or thin tubular shape and of wide surface areas to thereby extremely reduce a loss. Consequently, the problem raised in that a coil loss is conventionally very large to lower the radiation efficiency can be solved, the working gain can be improved, and an antenna, even when small-sized, can be realized to be fully practicable.

The elements 25, 25' comprises conductors 27a, 27a' extending horizontally and lengthwise and those 27b, 27b' extending perpendicular to the conductors 27a, 27a', the

conductors 27a, 27a', 27b, and 27b' being arranged in continuation and in rectangular wave-form. In such elements 25, 25', the conductors 27b, 27b' extending perpendicularly, as shown in Fig. 17-b, include conductors 27c, 27c' which are bent zigzag in a required number of times and larger in length than the conductors 27b, 27b'. The elements 25, 25', when turned through the feed terminals 26, 26' overlapped, are formed symmetrically to overlap transmitting conductor ways 27, 27' each other.

In addition, the above embodiment has the elements 25, 25' in which each one of the conductors perpendicular to the longitudinal direction of elements in bent zigzag only, alternatively, both the perpendicular conductors may be bent zigzag, in which it is convenient to eliminate flux component to make them symmetrically within one rectangular wave.

The number of times of zigzag bending, as shown in Fig. 19, is at least one or more enough.

Other than the zigzag bending of conductors perpendicular to the longitudinal direction of each element 25 or 25', the conductors, as shown in Fig. 20, are formed in a pattern of bending the conductors zigzag so that intervals between bending points become gradually closer as are extending from the feed terminals 26, 26'. Or, the conductors, as shown in Fig. 21, is formed in a pattern of making

intervals between the bending points rough widthwise of the elements as the conductors extend from the feed terminals 26, 26' lengthwise of the elements. Thus, a top loading effect is obtainable. The two-terminal variable reactance circuit, which is provided at the feeding sides of elements 25, 25' in the above embodiment, may alternatively be interposed within the antenna elements 25, 25' and connected thereto.

Fig. 22 shows still another example of antenna elements used for the antenna device of the invention, in which contracted antenna elements 28, 28' (hereinafter referred merely to elements 28, 28') have distributed constant inductance and employ metallic foil or wire of low electric resistance value, such as of copper, aluminum or iron, or conductive foil on the printed base and are formed in a pattern of bending the elements at the required points, in the respective directions and at angles, and in the required number of times. The elements 28, 28' are subjected to distributed constant inductance caused by bending the conductors and by arranging in continuation the conductors which are distributed alternately lengthwise of and perpendicular to the elements at the bending points and between each bending point, thereby being equivalent to the elements in the conventional example added with coils for eliminating reactance of elements as shown

in Figs. 1-a and 1-b. Hence, such elements 28, 28' are used to require no concentrated constant coils as conventional. The conductors, which are usable of material like foil or thin tube of a wide surface area, can extremely reduce a loss. Hence, the problem of a very lárge loss in coil and of lowering the radiation efficiency can be solved, the working gain can be improved, and an antenna, even small-sized, can be realized to be fully practicable.

In this instance, the elements 28, 28', as shown in Fig. 23-a, are bent at a given angle around the broken line and formed in nearly V-like shape extending lengthwise of the elements 28, 28', in which the element pattern is zigzag to thereby extremely restrict generation of flux in comparison with usual coils. The elements 28, 28', if composed of metallic foil or wire, are kept in bent condition by a base coincident with the bending form, and, if composed of metalic foil on the printed base employs a flexible base.

In addition, in this embodiment, the elements are bent nearly in a V-like shape. Alternatively, the elements 28, 28' may be bent at the broken lines 30, 31 as shown in Fig. 24-a and may be formed in a U-like shape as shown in Fig. 24-b, may be bent at the broken lines 30, 31 and 32 as shown in Fig. 25-a to be formed in an approximately W-like shape as shown in Fig. 25-b or nearly in

triangular as shown in Fig. 25-c, and may be bent at the broken lines 30, 31, 32 and 33 as shown in Fig. 26-a and formed in a rectangular shape as shown in Fig. 26-b. The elements may be formed in a rolled shape as shown in Figs. 28-a and -b, other than the above angular shape, in a overlapped rolled shape as shown in Figs. 28-a and -b, or in a circular arc as shown in Fig. 29.

Furthermore, the antenna elements, when attached to a transparent flexible base and used as it is plane, can be sticked to window glass, which is useful especially for an antenna device for a car radio.

As seen from the above, according to the invention, the antenna, which is very small in length in comparison with wave length in use and is tunable at individual frequency with respect to a whole zone in a required frequency range, is able to be composed of elements which have negative reactance small enough and are very small in its loss, and with a positive reactance control circuit small enough to offset and control the small negative reactance component of the element, that is, a positive reactance control circuit small enough in a loss. Thus, a plane antenna of high operation gain, super-small-sized, and lightweight is realizable. Hence, the antenna is easy to mount and increases in freeness for its installation. Also, the elements can actually be produced by etching the print

base or punching the metallic foil, thereby being easy to produce and inexpensive. When using the printed base, the element and circuity can be formed in a pattern simultaneously on the same base, thereby enabling integral formation, a low cost to manufacture, reduction of the number of processes, and improvement of reliability.

Since narrow-band characteristic is presented, the antenna is not tuned to signal other than tuning-desired signal and has interference signal shut-off capability, thereby making it possible to present good receiving performance with respect to the receiver to be connected. Furthermore, the element pattern, which is zigzag in continuation of transmitting conductor ways, is reducible in a space factor when rolled along the longitudinal direction of the element, and the coil-like shaped element generates no flux, thereby being usable as the antenna of high working gain.

Referring to Fig. 30, an antenna circuit 30 is constructed as follows: Reference numerals 35a, 35b designate a pair of antenna elements of bent conductors made from copper, alminum or iron, of low electric resistance value. The conductors are distributed alternately lengthwise of or perpendicular to the elements and arranged in continuation of each other so as to generate distributed constant inductance. Since the distributed constant inductance can

eliminate reactance of the antenna element, impedance looking from feed terminals 36a, 36b can be valued as the predetermined in the desired frequency. Also, material like foil or thin tube of a wide surface area is usable as the conductor, whereby a loss is considerably reducible. As a result, the antenna elements 35a, 35b small-sized more than the conventional one can be used to construct an antenna of large working gain. Reference numerals 37a, 37b designate variable reactance circuits connected to feed terminals 36a, 36b at antenna elements 35a, 35b respectively and having variable capacity diodes 38a, 38b as variable elements. When capacity values of diodes 38a, 38b are properly controlled to properly set resonance frequency fr of variable reactance circuits 37a, 37b changeable as shown in Fig. 4, the reactance component at the antenna elements 35a, 35b are controllable. In addition, reference numeral 39 designates a condenser for adjusting impedance and connected between feed terminals 36a, 36b, 40 designates a balance-unbalance converter, 41 designates a condenser for passing therethrough high-frequency receiving signal, 41 designates a high-frequency choke coil, and 43 designates an output terminal.

On the other hand, reference numeral 44 designates a high frequency stage of receiver, in which a well-known

high-frequency amplifier 45 and variable capacity diodes 48, 49 are interposed within resonance circuits 46, 47 respectively. Reference 50 designates a terminal connected to a second high-frequency amplifier or mixer, 51 designates a terminal applied with bias voltage to the variable capacity diodes 48, 49, 53 designates a high-frequency choke coil, 54 designates a condenser for passing therethrough high-frequency signal, and 55 designates an input terminal to the receiver 44.

The output terminal 43 at the antenna circuit 34 and the input terminal 55 at the receiver 44 are connected with each other through a high-frequency coaxial cable 56.

To realize the above connection, the above embodiment connects the antenna circuit and receiver 44 with a high-frequency coaxial cable 56, bias voltage applied to the variable capacity diodes 48, 49 from the terminal 51 of receiver 44 is applied to the variable capacity diodes 38a, 38b at the antenna circuit 34 through a switch 52, high-frequency choke coil 53, input terminal 55, high-frequency coaxial cable 56, input terminal 43, and high-frequency choke coil 42, thereby changing resonance frequency fr of variable reactance circuits 37a, 37b, thus enabling the antenna circuit 34 to tune by remote control from the receiver 44 side. In this instance, high-frequency receiving signal from antenna circuit 34 is of course

transmitted to the high-frequency stage through the condenser 41, input terminal 43, high-frequency coaxial cable 56, input terminal 55 and condenser 54.

In addition, in such receiving device, it is desirable to constitute the variable capacity diodes 38a, 38b at antenna circuit 34 of diodes of the same variation characteristic as the variable capacity diodes 48, 49 at receiver 44.

Alternatevely, the variable reactance circuit 37a, 37b may be interposed in other positions at antenna elements 2a, 2b or formed by series resonance circuit. Resistance of about 100 KΩ instead of the choke coils 42, 53 are used to be obtainable of the same effect. The switch 52, when using a usual antenna, is enough to be kept open.

In a case that the receiver 44 is formed in the so-called preset system, preset d.c. voltage is changed over to be applied to the terminal 51 in Fig. 30, in which the voltage is enough to be applied as bias voltage to the variable capacity diodes 38a, 38b at the antenna circuit 34.

When a variable condenser is used as the tuning element of receiver 44, d.c. voltage changing continuously is picked-up by changing volume in association with rotation of variable condenser, which is enough to be applied

to the variable capacity diodes 38a, 38b at antenna circuit 34.

As seen from the above, this invention connects by way of the high-frequency coaxial cable the receiver with the antenna circuit having small-sized antenna elements and using variable capacity diodes as the variable reactance element, so that d.c. voltage relating to the tuning element at the receiver is applied to the variable capacity diode at the antenna circuit by way of the high-frequency coaxial cable, whereby the tuning of antenna circuit is remote-controllable from the receiver side and the receiving device of very simple construction is provided to thereby obtain such superior effect.

In Fig. 31, an antenna circuit is constituted as follows: A pair of antenna elements 58a, 58b comprise bent conductors, such as copper, aluminum or iron, of low electric resistance value, the conductors being distributed alternately lengthwise of or perpendicular to the elements and arranged in continuation to thereby generate distributed constant inductance. Since the distributed constant inductance can eliminate reactance at the antenna elements 58a, 58b, impedance viewed from feed terminals 59a, 59b is made to be a given value at required frequency and foil-like or thin-tube-like conductors of wide surface area are usable to extremely

reduce a loss. As a result, the antenna of large working gain can be formed by use of antenna elements 58a, 58b small-sized more than the conventional ones. Variable reactance circuits 60a, 60b are connected to feed terminals 59a, 59b respectively, which have variable capacity diodes 61a, 61b as variable elements. Resonance frequency fr of variable reactance circuits 60a, 60b, which is properly controlled to vary the capacity values at diodes 61a, 61b as shown in Fig. 2, is properly set to enable control of the reactance component at the antenna elements 58a, 58b. In addition, reference numeral 62 designates a condenser for adjusting impedance and connected between the feed terminals 59a, 59b; 63 designates a balance-unbalance converter; 64 designates a high-pass filter for passing therethrough high-frequency receiving signal; 65 designates an output terminal; 66 designates a low-pass filter for passing therethrough control signal from the receiver; 67 designates a frequency divider; 68 designates a phase detector, 69 designates a low-pass filter; 70 designates a voltage control oscillator (VCO); and 71 designates a frequency divider, so that the phase detector 12 through frequency divider 71 constitutes a well-known PLL circuit, and the PLL circuit and frequency divider 67 constitute a frequency discriminator 72.

Reference numeral 73 designates the high-frequency

stage of receiver, 74 designates a synthesizer unit composed of the PLL circuit, 75 designates a reference oscillator, 76 designates a phase comparator, 77 designates a low-pass filter, 78 designates VCO, 79 designates a frequency divider, 80 designates a program counter, 81 designates a low-pass filter for passing therethrough output signal of the frequency divider 79, 82 designates a high-pass filter for passing therethrough high-frequency receiving signal from the antenna circuit 57, 83 designates an input terminal of receiver, 84 designates a terminal connected to the front end, 85 designates a terminal connected to a mixer, and 86 designates a terminal applied with code for setting receiving frequency. The output terminal 65 at the antenna circuit 57 and input terminal 83 at the receiver 73 are connected with each other through a high-frequency coaxial cable 87.

In order to actually complete the above constitution, in the above embodiment, output of the frequency divider 79 at the synthesizer unit 74 provided at the receiver 73 is adapted to be used as control signal. In detail, the control signal is fed to the antenna circuit 57 by way of the low-pass filter 81, input terminal 83 and coaxial cable 87, and is applied to the frequency divider 67 by way of the low-pass filter 66, and, after stepped down to proper frequency, is applied to PLL circuits 68 to 71, so that

d.c. voltage corresponding to the frequency of control signal is picked-up from the output side of low-pass filter 69 and applied to the variable capacity diodes 61a, 61b. By this, remote control of tuning is possible from the receiver 73 side. High-frequency receiving signal from antenna circuit 57 is output to the input terminal 65 through the high-pass filter 64 and fed to the front end through the coaxial cable 87, input terminal 83, high-pass filter 82 and terminal 84. In addition, numerals in Fig. 31 represent exemplary frequencies within FM band (receiving frequency 76MHz to 90MHz) in Japan.

Alternatively, the frequency discriminator 72 may employ a pulse-count wave-detector, Foster-Seeley type wave-detector, ratio type wave-detector, double staggered resonance type wave-detector, or slope wave-detector. When the division ratio of frequency divider 67 is properly set, the output of VCO of course may be used, as it is, for control signal. The variable reactance circuits 60a, 60b may be connected to the positions other than shown.

As seen from the above, the antenna device of the invention is so constructed that the antenna circuit having the small-sized antenna elements is provided with the frequency discriminating circuit, and VCO output of frequency division output thereof in the synthesizer receiver

is supplied as tuning control signal to the frequency discriminating circuit, so that d.c. voltage output by the frequency discriminating circuit may be applied to the variable capacity diodes provided at the antenna circuit, thereby making it possible to remote-control the tuning of antenna circuit from the receiver side for superior receiving ability.

An antenna circuit shown in Fig. 32 is constituted as follows: A pair of antenna elements 89a, 89b comprise bent conductors, such as copper, aluminum, or iron, of low electric resistance value, the conductors being distributed alternately lengthwise of and perpendicular to the elements and arranged in continuation, thereby generating distributed constant inductance. The distributed constant inductance, which is able to eliminate reactance of the antenna elements, enables impedance viewed from feed terminal 90a, 90b to have a given value at required frequency and conductors of foil-like or thin tube-like shape wide in surface area are usable to extremely reduce a loss. As a result, use of antenna elements 89a, 89b small-sized as compared with the conventional ones can construct an antenna of large working gain. Variable reactance circuits 91a, 91b are connected to the feed terminals 90a, 90b at antenna elements 89a, 89b and provided with variable capacity diodes 92a, 92b

variable elements respectively. Resonance frequency fr in variable reactance circuits 91a, 91b changeable, as shown in Fig. 4, by proper control of capacity values of diodes 92a, 92b is properly set to enable control of reactance component of antenna elements 89a, 89b. In addition, reference numeral 154 designates a condenser connected between the feed terminals 90a, 90b and for adjusting impedance, and 93 designates an input terminal for control signal.

While, first and second control circuits 94, 95 are constituted as follows: The first control circuit 94 comprises an optical receiver 96 receiving optical codes, a light-electricity converter 97 for converting the output of optical receiver into quantity of electricity, a latch circuit 98 to latch said output, and a digital-to-analog converter to convert the output of latch circuit 98 into analog voltage. The second control circuit 95 comprises a code generator 100 to generate codes for setting frequency and an electricity-light converter 101 for converting the codes into light (especially infrared rays).

In order to actually perform the above, the above embodiment once converts code for setting frequency into optical code, the optical code is converted into code of quantity of electricity after ptical receipt and then into analog voltage, thereby being applied to variable

capacity diodes 92a, 92b.

Hence, digital signal is usable to control the tuning of small-sized antenna. The first and second control circuits, which are disposed apart from the antenna circuit, enable remote control. Furthermore, when the first control circuit is incorporated with the antenna circuit and the second control circuit only is apart therefrom, or both the first and second control circuits are apart from the antenna circuit, the remote control also is possible, thereby considerably increasing freeness for a design of remote control. Moreover, a frequency code generator, when used for controlling a variable frequency divider at PLL of synthesizer tuner as a code generator for setting frequency, can be simply added to a conventional synthesizer tuner using an usual antenna.

In Fig. 33, on a base 102 of print wirings are printed antenna element patterns 103, 103' and distributed constant inductance coils 105, 105' as inductance of components for tuning circuits connected to pattern joints 1 104, 104' at the feed terminal side of element patterns 103, 103'. On the print base 102 are printed; lead wire routes from the joints 104, 104' to terminals 107, 107' connected to variable condensers 106, 106' as variable capacitance of another components at the tuning circuits; lead wire routes from the other terminals 108, 108'

connected to the variable condensers 106, 106' to the other pattern joints 109, 109'; and lead wire routes from the pattern joints 109, 109' to feed terminals 110, 110'. An impedance adjusting condenser 111 is connected between the feed terminals 110 and 110'. The variable condensers 106, 106', other components of tuning circuits, and the impedance adjusting condenser 111 are mounted at lead terminals at both ends directly on the lead wire routes between the terminals 107, 107' and 110, 110', or inserted into bores bored at the lead wire routes.

Fig. 34 shows a yet further embodiment of antenna system of the invention. In Fig. 34, on a print-wiring base 112 are printed antenna element patterns 113, 113' having the distributed constant inductance, and is printed a distributed constant inductance coil 115 serving as inductance of component in the tuning circuit and connected between pattern joints 114 and 114' at the feeding side of element patterns. On the print-wiring base 112 also are printed lead wire routes extending until a terminal 117 connecting a variable condenser 116, is printed a lead wire route extending from the other terminal 117' connecting the variable condenser 116 with the pattern joint 114': other end of inductance coil 115, and are printed lead wire routes connecting to an earth terminal 119 and feed terminal 120 the secondary coil 118, which

together with the primary coil 115 forms a transformer. The transformer is provided with balance-unbalance made change function as well as impedance change function. The variable condenser 116: the other component of tuning circuit, is mounted at both end lead terminals directly on the lead wire routes to joints 117, 117', or inserted into bores formed at the routes.

In addition, in the above embodiment, antenna elements 103, 103', 113 and 113' and inductance coils 105, 105' and 115 are each formed in a simply zigzag pattern, may of course be formed of a desired pattern having a required inductance value.

As seen from the above, this invention can reduce the number of parts and improve workability, thereby providing an antenna of a very low cost to produce. Elements and coils are mass-productive in the same pattern, reducible considerably of dispersion in the electrical constant. Also, the elements and coils, which are of plane patterns of distributed constant and of no closed loop of current passage, generate no magnetic flux. On the contrary, they are not affected by external magnetic flux and these distributed constant inductance elements or coils can decrease in a loss more than those of concentrated constant inductance, thereby being largely advantageous in improvement in working gain; stability, and reliability. Further-

more, the antenna of plane pattern can actually be provided to thereby increase freeness for installation or design.

Figs. 35 through 39 are views explanatory of an antenna system of the invention, in which band change-over and tuning at an antenna and receiver are associated with each other so that tracking for the antenna and receiver is always carried out in a wide range of tuning frequency without changing a fixed number of parts constituting the antenna elements and tuning circuits.

Generally, in antennas of tuning type, impedance possessed by antenna elements and a range of variable-adjusting tuning circuits connected to the elements, are determined by each structural form or material and are limited thereto. Hence, these tuning antennas have the tuning frequency range limited not to optionally change it, whereby a problem is raised in that it is inconvenient to carry out tracking in connection with other tuning systems.

This invention aims at providing an antenna system of tuning type, which is capable of overcoming such conventional problem and of desirably adjusting a tuning frequency range, and also aims at a receiving device always coincident with a receiver in a receiving band and tuning frequency.

Next, an embodiment of the receiving device of invention will be detailed in accordance with the drawings.

Fig. 35 is a block diagram of basic constitution of receiving device of the invention, in which reference numerals 121, 121' designate antenna elements to which change-over control reactance circuits 122, 122' are connected. A tuner 123 and a balance-unbalance mode converter 124 (hereinafter referred merely to balance) are connected to the change-over control reactance circuits 122, 122'. An unbalance output terminal 124a at the balance 124 is connected with an antenna input terminal 125a of receiver 125 through a coaxial cable. Band change-over signal itself obtained by change-over of receiving band at the receiver 125, or band change-over control signal converted into desired signal form, is output from a band change-over control signal output terminal 125b at the receiver 125 by way of a line and then fed to the change-over control reactance circuits 122, 122'. The change-over control reactance circuits 122, 122' set plus and minus signs of reactance and a value of reactance corresponding to the band change-over control signal, the set reactance being added in series to the antenna elements 122, 122'. Tuning control signal itself by obtained the setting of tuning frequency at receiver 125, or tuning control signal converted into the desired signal form, is output from a tuning control signal output terminal 125c at receiver 125 through the line and fed to the tuner 123,

whereby, in the set band, the receiver 125 and antenna unit 126 are kept always to obtain tracking. In the above description, the dipole antennas are exemplified by a pair of antenna elements 121, 121'. Alternatively, a mono-pole type antenna of single antenna element may be applicable. Instead of the balance 124 converting the unbalance output signal, the balance output signal as it is may be fed to the receiver 125 providing a balacne antenna input terminal. Also, the change-over control reactance circuits 122, 122' may be disposed at intermediate positions within the antenna elements 121, 121' respectively.

In Fig. 36, only impedance at frequencies $\underline{f_1}$ to $\underline{f_2}$ of distributed constant inductance elements 127, 127' is represented by a curve <u>A</u> in Fig. 37-b. Fixed condensers 128, 128', 129 and 129' and fixed coils 130, 130', 131 and 131' are connected to the elements. Change-over control reactance circuits 135, 135' comprising change-over switches comprising switches 132, 132' and exciting coils 133, 133' and being changed over to a required change-over terminal, are connected to the elements, so that, for example, when the switches 132, 132' are changed over to connect the fixed coils 131, 131', the impedance turns on the curve <u>B</u> in Fig. 38. In a case that between the parallel resonance variable reactance circuits comprising a coil

136, variable condenser 137, condenser 138, a coil 136', variable condenser 137', and condenser 138', and the feed terminals 139, 139', is interposed a tuning circuit 141 comprising an impedance adjusting condenser 140, the impedance at $\underline{f_1}$ to $\underline{f_2}$ turns until the curve D shown by the broken line in Fig. 38-a, alternatively becomes tunable in a frequency range of $\underline{f_0}$ to $\underline{f_1}$ lower than $\underline{f_1}$ to $\underline{f_2}$ shown by the curve E. On the contrary, in Fig. 36, when the switches 132, 132' are changed over to connect to the distributed constant inductance elements 127, 127', for example, the fixed condensers 128, 128', the impedance turns on the curve C in Fig. 38-b. Furthermore, when the tuning circuit 141 comprising impedance adjusting condenser 140 is connected between the feed terminals 139, 139' and the parallel resonance variable reactance circuits comprising the coil 136, variable condenser 137, condenser 138, coil 136', variable condenser 137', and condenser 138'; the impedance at $\underline{f_1}$ to $\underline{f_2}$ turns until the curve F only as shown by the broken line in Fig. 38-b, and alternatively becomes tuable in a frequency range of $\underline{f_2}$ to $\underline{f_3}$ higher than $\underline{f_1}$ to $\underline{f_2}$ shown by the curve G, where the variable condenser 137, 137' change in a value of electrostatic capacity by tuning control signal applied to the terminal 142, and resistances 143, 143' 144 and 144' are provided for blocking high-frequency. When reactance of each fixed coil 130, 130',

131, 131' is set independently to a desired value, the coils are changed over to make it possible to optionally select a range of tunable frequency. In order to get tracking at receiver 125 and tuning frequency in Fig. 35, band change-over control signal corresponding to band change-over within the receiver 125 is given to the terminal 134, and the tuning control signal corresponding to the tuning control to the terminal 143. In addition, in the above explanation, four kinds of fixed condensers and fixed coils are represented, but required plural kinds of them may of course be provided correspondingly to required change-over bands.

In the above description, the parallel resonance variable reactance circuit is used in the tuning circuit 141. Alternatively, a series resonance variable reactance circuit may of course be used. The variable capacity elements 137, 137' as the variable reactance elements has hitherto been described, but variable inductance elements of course may be used to form the resonance circuit.

Fig. 39 shows a modified embodiment of the receiving device of the invention, in which control signal is superposed between the receiver and the antenna unit. At the tuning control signal output terminal 125c of receiver 125 is provided a low-pass filter 147 for blocking receiving high-frequency signal and passing d.c. tuning control

signal, the output terminal being connected with a receiving signal feeding line 151. On the other hand, at the band change-over control signal output terminal 125b is provided a band-pass filter for blocking receiving high-frequency signal and d.c. tuning control signal and passing pulse train signal having a required repeat period, repeat innings, or required different pulse-height, the output terminal being connected to the receiving signal feeding line 151. At the antenna unit 126 side is disposed a low-pass filter 149 of the same characteristic as the low-pass filter 147. The low-pass filter 149 is connected at its input terminal to the receiving signal feeding line 151 and at its output terminal to a terminal 152 connected to the tuning control signal terminal within the antenna unit 126. While, a band-pass filter 150 of characteristic identical with that of the aforesaid band-pass filter is provided to connect at its input terminal with the receiving signal feeding line 151 and at its output terminal with a terminal connected to the band change-over control signal terminal 134 within the antenna unit 126. In this instance, when the change-over control reactance circuit within the antenna unit 126 employs a fixed reactance element, a latch (not shown) is provided to dispose pulse signal for band change-over signal fed between the terminal 153 and the band change-over control signal

terminal 153, and when using a variable reactance element, the latch and digital-analog signal converter (not shown) are provided. The pulse signal for band change-over control signal can be judged from a range of changing d.c. level of tuning control signal. In order to prevent the tuning control from being affected to be disturbed by the pulse signal, wave-detection output muting within a receiver 125 is allowed to work only when changing over the band.

In this instance, the receiver 125 in Fig. 35 may be of a closed loop synthesizer system utilizing PLL for a local oscillator performing the tuning control of receiver, of an open loop synthesizer system utilizing a D/A converter, or of a basically electionical tuning system by manual or automatic sweeping voltage control, the tuning control signal is enough to be fed into tuning circuit at antenna unit 126.

As seen from the above, the antenna system of the invention, with respect to the receiver necessary to tune in a very wide range of frequency, exchanges no antenna element, changes no length thereof, and is tuned to each frequency, thereby constructing the antenna unit of high working gain throughout the frequency band to be received, thus providing the receiving device of very wide frequency range in cooperation with the receiver. Each time the band change-over signal from the receiver changes over

reactance of change-over control reactance circuit at the antenna unit, the tuning control signal of tuning circuit is repeatedly supplied for use in a range of change, whereby the tuning circuit is simple in construction while the receiving device is very wide in a range of tuning frequency, and variable reactance elements usual but not particular are usable to be very practicable. Especially, FM stereo band, VHF TV band, and UHF TV band for public welfare receiving, are receivable only by a receiving device comprising a set of antenna unit and receiver to thereby eliminate inconvenience of receiving by separate antenna units and receivers for each band and also increase portions in common use, thus enabling the device to be considerably inexpensive to produce. Especially, use of the zigzag type contracted antenna elements can provide the antenna unit very small-sized and of high working gain to thereby provide the device extremely small-sized and of high efficiency.

Figs. 40 through 43 are views of explanatory of the antenna unit of the invention.

Fig. 40 shows an embodiment of a phase difference feed type antenna device of the invention, in which reference numerals 158, 159 designate a first and a second dipole antenna opposite to each other at a regular distance, 160 designates control means in common to the first and second dipole antennas 158, 159, and 161 designates

signal composing means connected to the first and second dipole antennas 158, 159. The second dipole antenna 159 is disposed at a phase difference of 180° with respect to the first dipole antenna, both the dipole antennas being coupled with signal composing means 161 through coaxial cables 156, 157 each of different length, so that signal is led to a feed terminal 155 of signal composing means 161.

Now, if the first dipole antenna 158 is disposed at the front F side and the second one 159 at the back B side and lengths of coaxial cables 156, 157 are represented by $\underline{\ell_1}$, $\underline{\ell_2}$ respectively, a distance $\underline{d}$ between the opposite dipole antennas 158, 159 can be obtained by the following equation (1):

$$d = K(\ell_1 - \ell_2) \qquad \ldots\ldots (1)$$

where K: wave-length contraction ratio of 0.68 and $\ell_1 > \ell_2$.

Directivity of such phase difference feed type antenna device is shown in Fig. 6 and the frequency to gain characteristic in Fig. 42.

In addition, in the above embodiment, the first and second dipole antennas 158, 159 are disposed opposite to each other at phase difference of 180°. Alternatively, both the dipole antennas 158, 159 may be disposed opposite in-phase so that the second dipole antenna may be connected to the signal composing means 161 by way of a phase con-

verter 25.

Figs. 44 through 47 are views of explanatory of a modified embodiment of antenna unit of the invention.

Fig. 43(a) shows the modified embodiment of antenna device of the invention, in which reference numerals 164, 165 and 166 designate first, second and third dipole antennas disposed opposite to each other at each interval of $\lambda/4$. The second dipole antenna is used as a radiator so as to have a feed terminal 167. The first dipole antenna 164 is disposed at the front F side of the second dipole antenna 165 as the radiator and is in-phase to the antenna 165, thereby being used as a wave director. The third dipole antenna 166 is disposed at the back B side of second dipole antenna 165 as the radiator and is in-phase to the dipole antenna 165, thereby being used as a reflector. Reference numeral 163 designates control means in common to the first, second and third dipole antennas as the radiator, wave-director and reflector respectively.

The directivity characteristic of antenna device using such dipole antennas and having the wave-director and refector is represented by the curve a in Fig. 44, and the frequency to gain characteristic by the curve a in Fig. 45.

In addition, in the above embodiment, the wave director and reflector are attached to the front and rear of radiator, but at least either wave director or reflector is enough

to be attached as shown in Figs. 46 and 47. The directivity and the frequency to gain characteristics are represented by the curves b, c in Figs. 44 and 45.

CLAIMS:

1. An electronic tuning antenna system, characterised in that there are provided:

a pair of antenna elements (15,15') which are adapted to have distributed constant inductance by being in the form of conductors bent at desired points;

an antenna circuit comprising variable reactance circuits (16, 17, 18) connected to each of said elements, said variable reactance circuits including variable capacity diodes (17), and an impedance adjusting reactance element (23) interconnected between feed terminals (22, 22') of said pair of antenna elements; and

a communications apparatus arranged to be connected via a coaxial cable to said antenna circuit whereby electrical signals associated with the conversion between electromagnetic radiation and electrical signals at said antenna elements pass through said coaxial cable, said communications apparatus including a control circuit (19,20) for providing control signals fed to said antenna circuit and arranged to generate controllable bias voltages on said variable capacity diodes, thereby to tune said antenna system.

2. An electronic tuning antenna system, characterized in that a pair of antenna elements which are adapted to have distributed constant inductance by bending transmitting conductor ways, variable reactance circuits connected to each of said antenna elements in proper positions thereof and having variable capacity diodes, an antenna circuit having an impedance adjusting condenser interconnected between feed terminals of said pair of antenna elements, and a receiver for regenerating high-frequency receiving signal from said antenna circuit, are provided so that an output terminal of said antenna circuit and an input terminal of said receiver are connected with each other through a high-frequency coaxial cable to thereby transmit high-frequency receiving signal from said antenna circuit by way of said high-frequency coaxial cable, and d.c. voltage relating to the tuning element at said receiver is adapted to be applied as bias voltage to said variable capacity diodes at said variable reactance circuits through said high-frequency coaxial cable.

3. An electronic tuning antenna system, characterized in that a pair of antenna elements which are adapted to have distributed constant inductance by bending transmitting conductor ways, variable reactance circuits connected to each of said antenna elements in proper positions there-

of and having variable capacity diodes as variable reactance elements, an antenna circuit having an impedance adjusting condenser interconnected between feed terminals at said pair of antenna elements and a frequency discrimination circuit, and a synthesizer receiver having a PLL circuit, are provided so that an output terminal of said antenna circuit and an input terminal of said receiver are connected with each other through a high-frequency coaxial cable to thereby transmit high-frequency receiving signal from said antenna circuit by way of said high-frequency coaxial cable, and output of VCO or frequency division thereof at the PLL circuit of said receiver is applied to said frequency discriminator at said antenna circuit so that the output of said frequency discriminator is applied to the variable capacity diodes at said antenna circuit.

4. An electronic tuning antenna system, characterized in that a pair of antenna elements which are adapted to have distributed constant inductance by bending transmitting conductor ways, variable reactance circuits connected to each of said antenna elements in proper positions thereof and having variable capacity diodes as variable reactance elements, an antenna circuit having an impedance adjusting condenser interconnected between the feed terminals at said pair of antenna elements, and control cir-

cuits for applying tuning control voltage to said antenna circuit, are provided so that said control circuits comprise a generator for generating codes for frequency-setting, an electricity-light converter for converting output of said generator into optical codes, an optical receiver receiving the optical codes from said electricity-light converter, a light-electricity converter for converting the output of said optical receiver into quantity of electricity, a latch circuit to latch the output of said light-electricity converter, and a digital-analog converter for converting the output of said latch circuit into analog voltage, whereby the output of said digital-analog converter is applied to said variable capacity diodes at said antenna circuit.

5. An electronic tuning antenna system according to claim 1,2,3 or 4 wherein said antenna circuit is provided with an antenna body comprising a pair of antenna elements which comprise transmitting conductor ways each formed continuously in a zigzag shape and have distributed constant inductance, two-pole variable reactance circuits connected to said pair of antenna elements in positions thereof respectively, and, separately, control means for manually variable-controlling reactance of said two-terminal variable reactance circuit, whereby said antenna circuit provided between terminals at said antenna body with said impedance

adjusting condenser is capable of optinally changing over tuning control of said antenna circuit into manual control or automatic control corresponding to its purpose to use.

6. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said pair of antenna elements comprising the antenna body are connected mutually at the reverse side to the feed terminal with symmetrical transmitting conductor ways.

7. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna circuit is provided with; a pair of antenna elements whose transmitting conductor ways are zigzag shaped in continuation and which have distributed constant inductance and are formed in a further zigzag shape within said formation of zigzag shape so as to increase a value of said distributed constant inductance; a two-terminal variable reactance circuits connected to said pair of antenna elements respectively; and an impedance adjusting condenser interposed between the feed terminals at said pair of antenna elements.

8. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna elements formed in zigzag shapes of vertical conductors perpendicular to the longitudinal direction of said ele-

ments and horizontal conductors parallel to the longitudinal direction, said vertical and horizontal conductors are bent at right angles in continuation, and that said vertical conductors are constituted in a pattern of at least one turn-back to thereby have distributed constant inductance.

9. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna elements at said antenna circuit are constituted in a pattern of making the continuous zigzag form close sequentially lengthwise of said elements.

10. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna elements at said antenna circuit are constituted in a pattern of making the continuous zigzag form gradually larger in width perpendicular to the longitudinal direction of said elements.

11. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna circuit is provided with; a pair of antenna elements which comprise transmitting conductors formed in zigzag shape in continuation, have distributed constant inductance, and are rolled roundly or angularly around the lengthwise line of each of said elements; two-terminal variable reactance circuit connected to said pair of antenna elements respectively; and an impedance adjusting condenser interconnected between the feed terminals of said pair of antenna elements.

12. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that on a print-wiring base are printed; a required antenna element pattern and an inductance element pattern constituting a tuning circuit; a lead wire way pattern for connecting said antenna element pattern with said inductance element pattern; and a lead wire way pattern for mounting and connecting element parts of other components of said tuning circuit with respect to said inductance element pattern.

13. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna circuit is provided with; at least one or more antenna elements having a tuning circuit; an antenna unit provided within said antenna element or between said antenna element and said tuning circuit with a change-over control reactance circuit comprising a plurality of fixed reactance elements and selective change-over switches for selectively changing over said fixed reactance elements; a receiver whose antenna input terminals are connected with the feed terminals of said antenna unit; a band change-over control line provided and connected to controllably change over said selective change-over switches by band change-over signal sent from said receiver; and a tuning control line provided and connected to tuning-control said tuning circuit by the tuning control signal sent from said

receiver; so that said receiver is associated with the receiving band change-over and tuning control of said antenna unit, thereby always allowing said receiver to coincide in tuning frequency with said antenna unit in a wide range.

14. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna circuit is provided with; a pair of antenna elements comprising transmitting conductor ways formed in zigzag shapes in continuation and having distributed constant inductance; two-terminal variable reactance circuits connected to said pair of antenna elements respectively; first and second dipole antennas which are provided with an impedance adjusting condenser provided between the feed terminals at said pair of antenna elements and are disposed opposite to each other at the prescribed interval; a signal composing device being connected through a feed way of different or equal length with respect to said first and second dipole antennas and composing a first signal from said first dipole antenna and a second signal from said second dipole antenna; and control means for variably controlling reactance of said two-terminal variable reactance circuits constituting said first and second dipole antennas.

15. An electronic tuning antenna system according to claim 14, characterized in that said antenna circuit em-

ploys a phase difference feed type antenna circuit in which said first and second dipole antennas are disposed opposite to each other so as to be in-phase and a phase converter is provided between said second dipole antenna and said signal composing device.

16. An electronic tuning antenna system according to any one of claims 1 to 5, characterized in that said antenna circuit is provided with; a dipole antenna for a radiator, which connects each of the pair of antenna elements comprising transmitting conductor ways formed in zigzag shapes in continuation and having distributed constant inductance, with a two-terminal variable reactance circuit, and interconnects an impedance adjusting condenser between the feed terminals of said pair of antenna elements; a dipole antenna for a wave director and/or radiator, which is disposed at least one side of front and rear sides of said dipole antenna for the radiator and opposite to said dipole antenna at an interval of $\lambda/4$ of wave length of frequency in use, connects each of said pair of antenna elements comprising transmitting conductor ways in continuation and having the distributed constant inductance, with said two-pole variable reactance circuit, and interconnects an impedance adjusting condenser and matching resistance between the feed terminals at said pair of antenna elements; and control means for variably control-

ling reactance of said two-terminal variable reactance circuit constituting said dipole antenna for the radiator and said dipole antenna for the wave director and/or radiator.

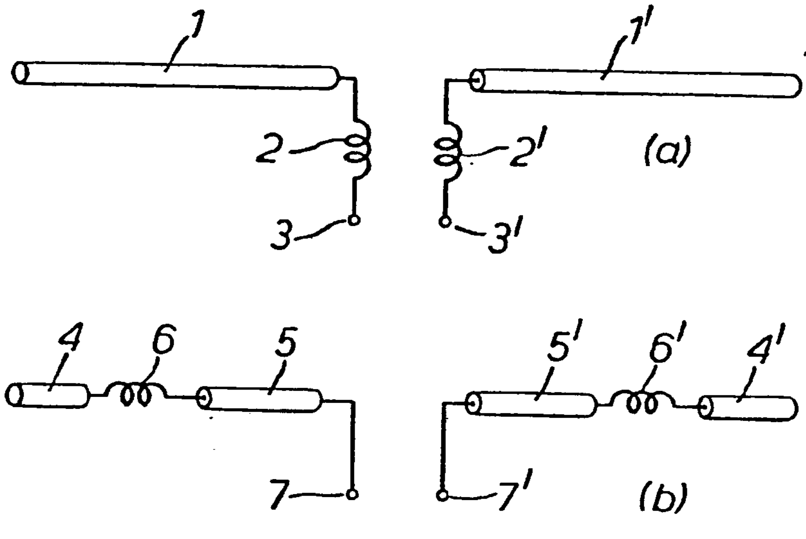


FIG. 1.

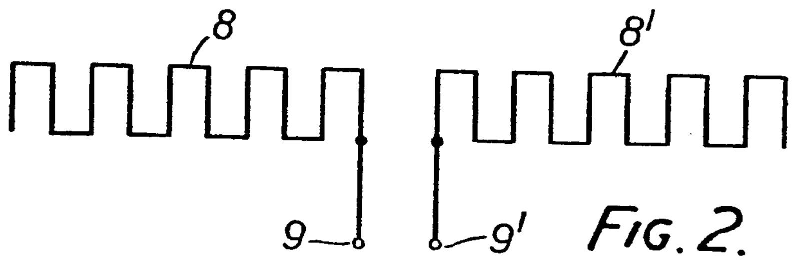


FIG. 2.

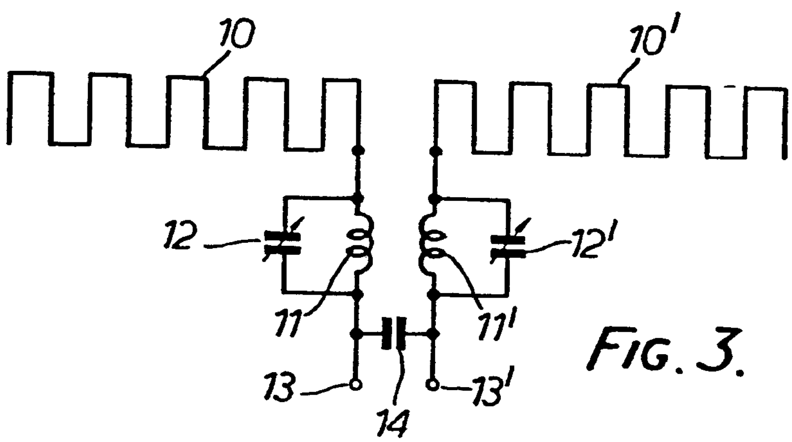
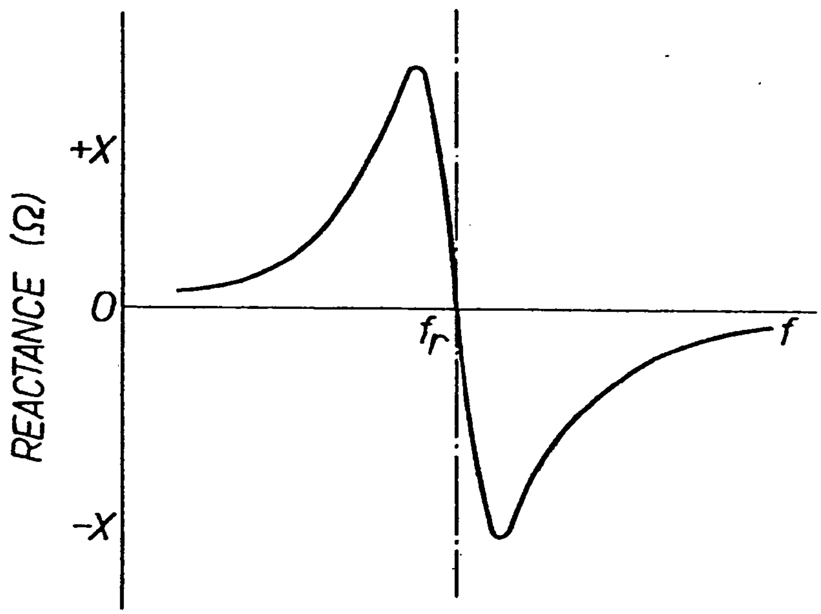
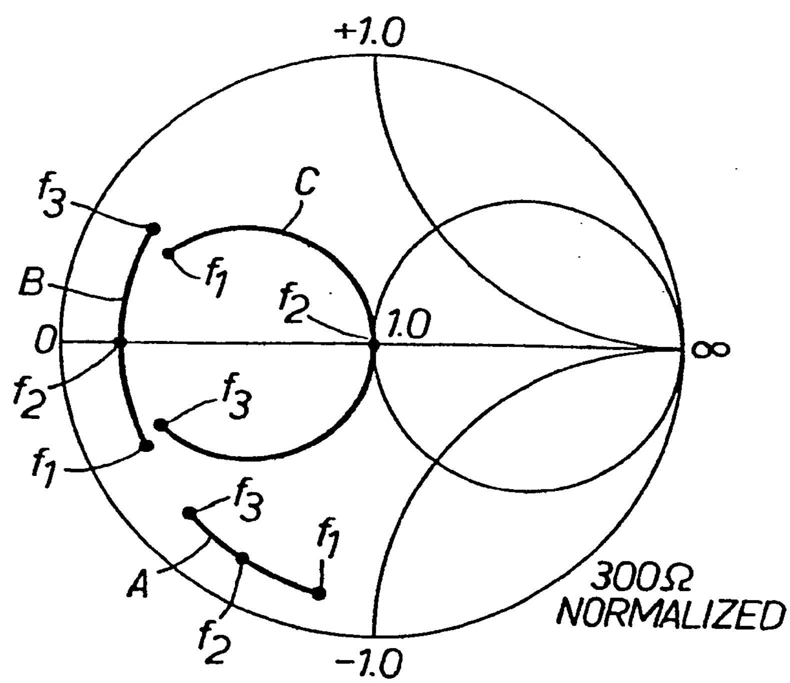


FIG. 3.



+X
REACTANCE (Ω)
0
f_r
f
-X

FIG. 4.



+1.0
C
f_3
f_1
B
f_2
1.0
0
∞
f_2
f_3
f_1
f_3
f_1
A
300Ω
NORMALIZED
f_2
-1.0

FIG. 5.

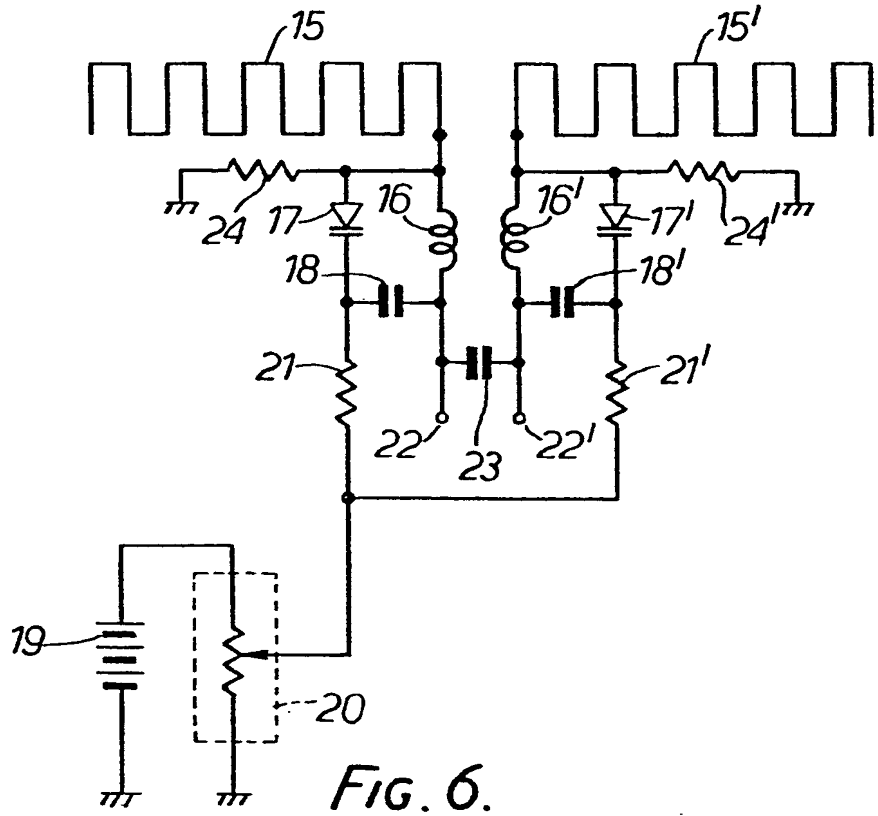


FIG. 6.

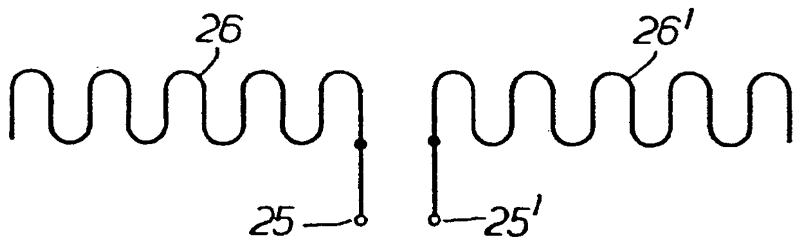


FIG. 7.

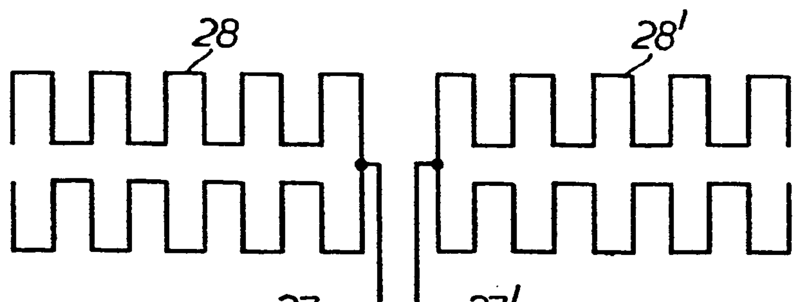


FIG. 8.

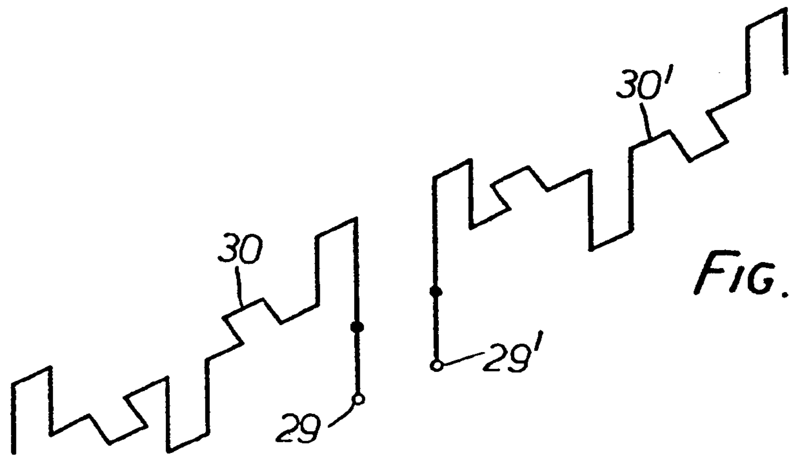


FIG. 9.

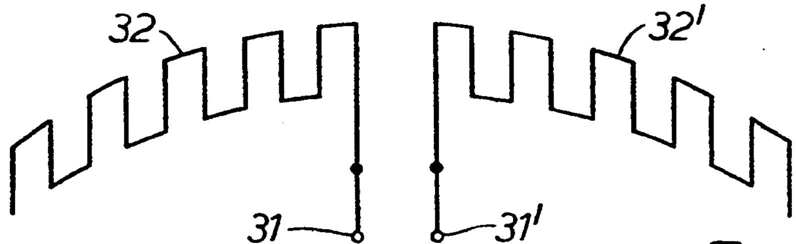


FIG. 10.

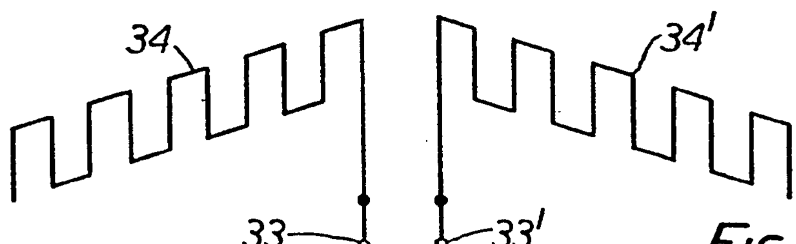


FIG. 11.

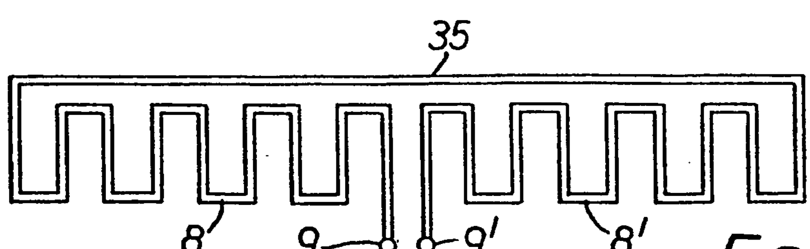


FIG. 12.

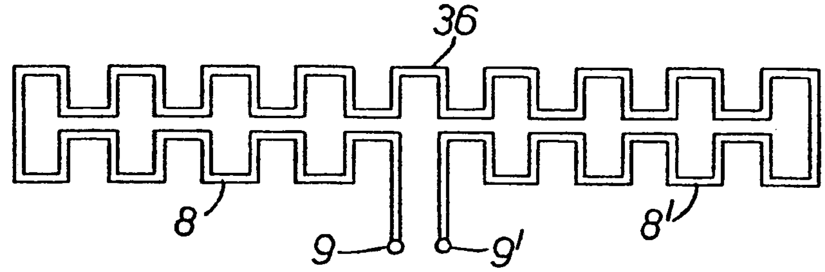


FIG. 13.

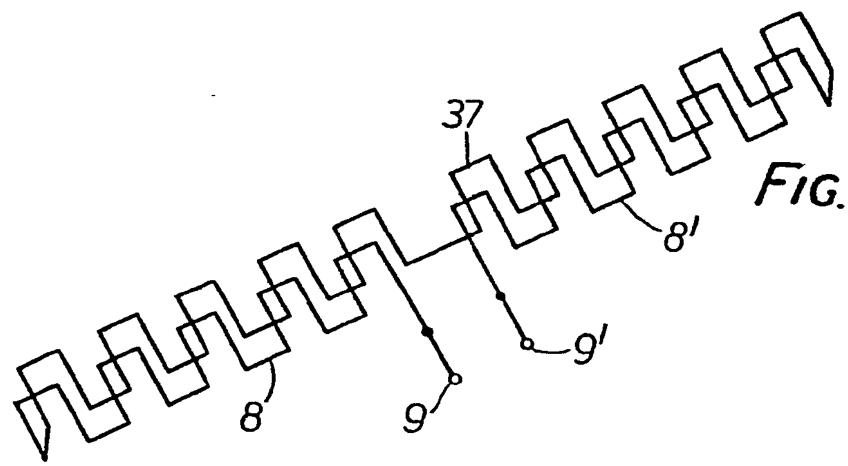


FIG. 14.

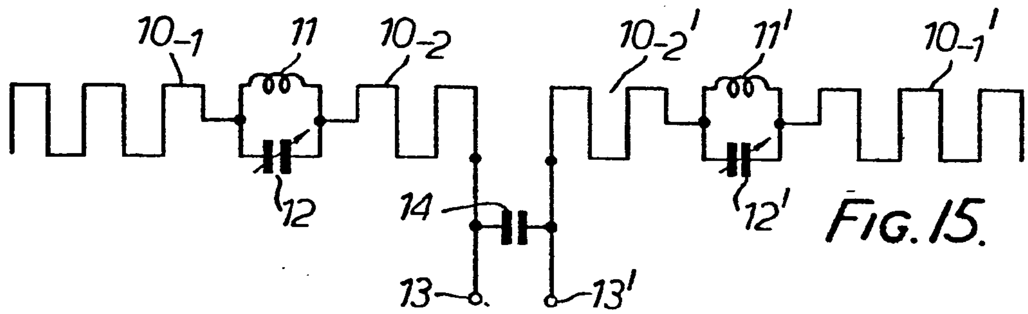


FIG. 15.

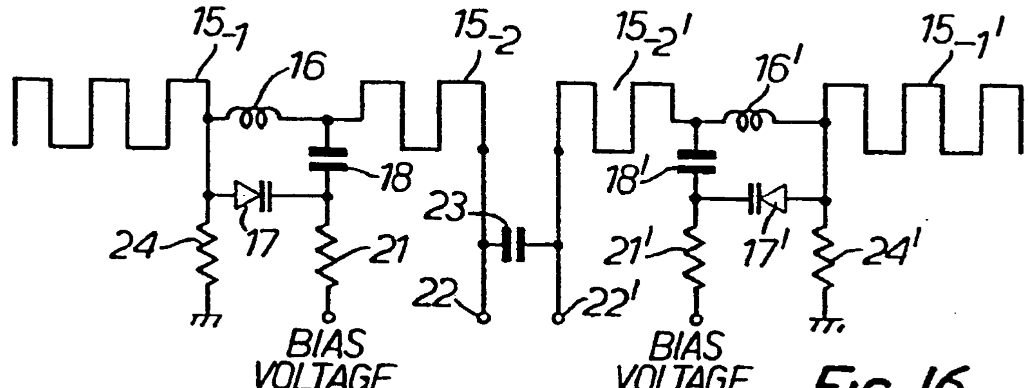
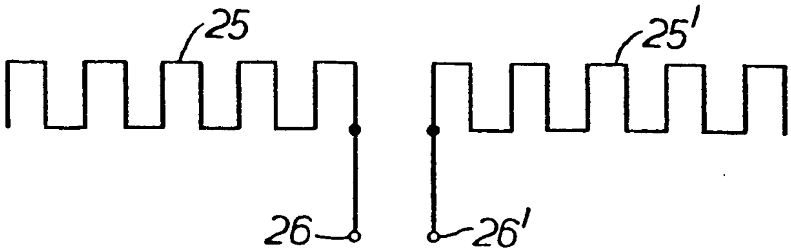
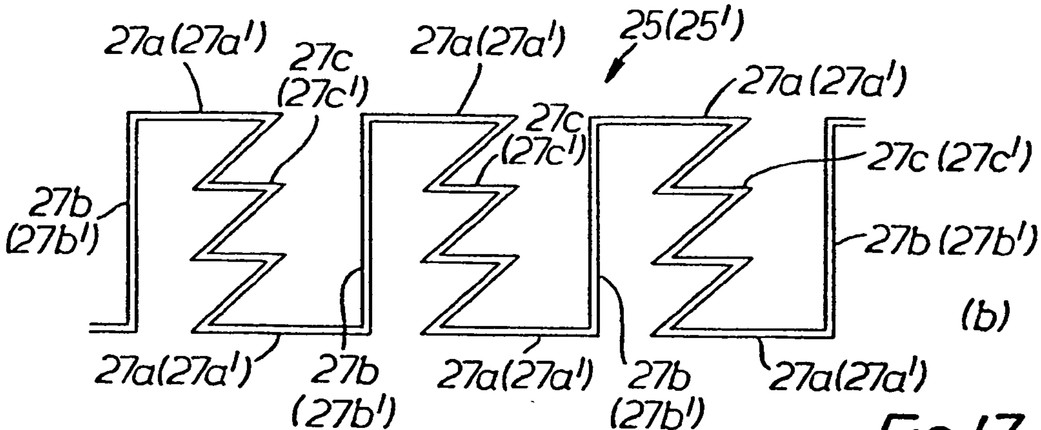


FIG. 16.



(a)



(b)

FIG. 17.

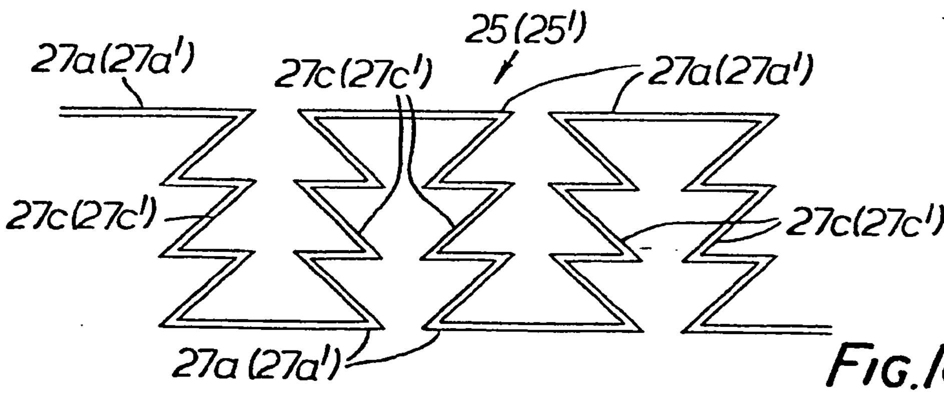


FIG. 18.

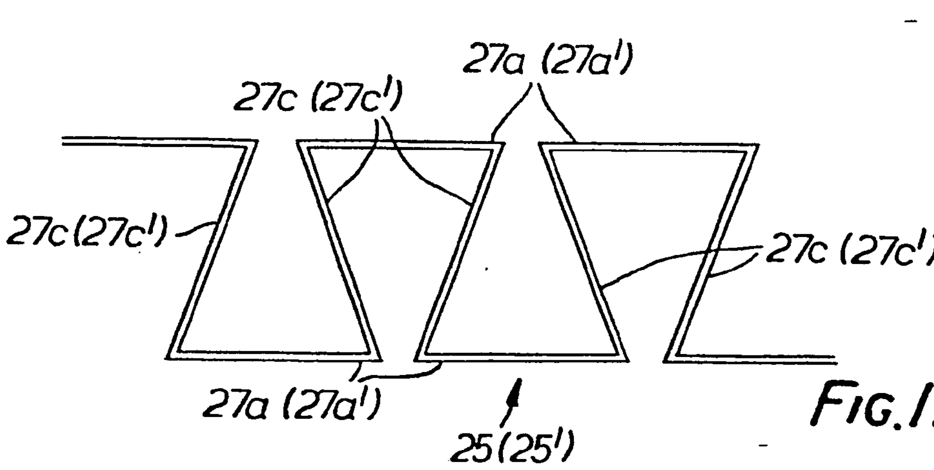


FIG. 19.

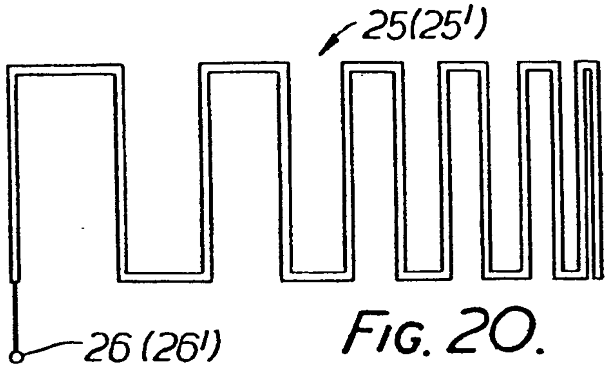


FIG. 20.

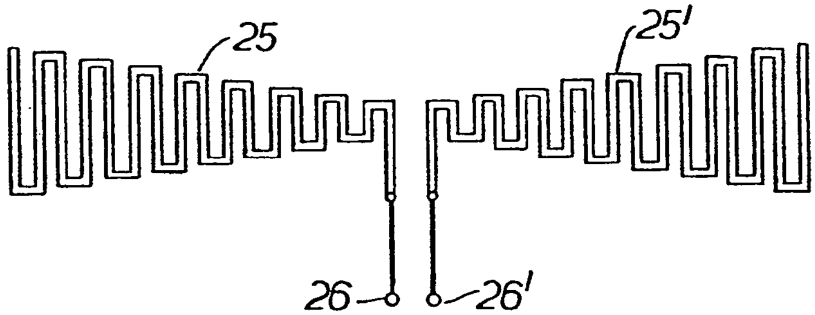


FIG. 21.

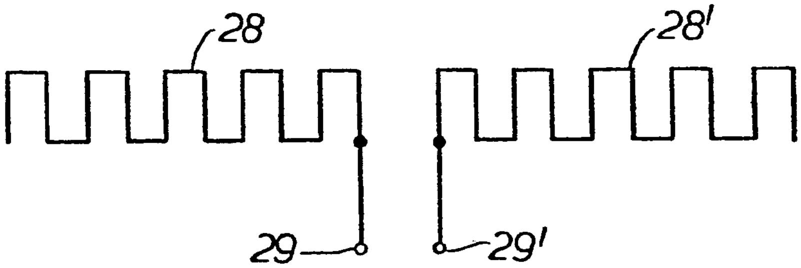


FIG. 22.

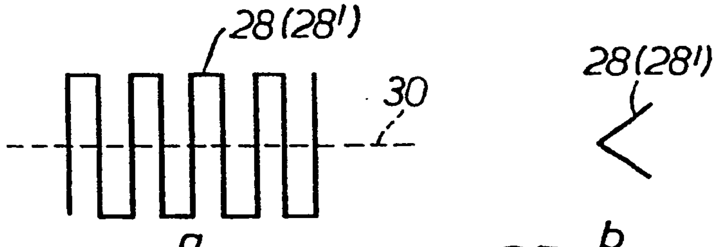


FIG. 23.

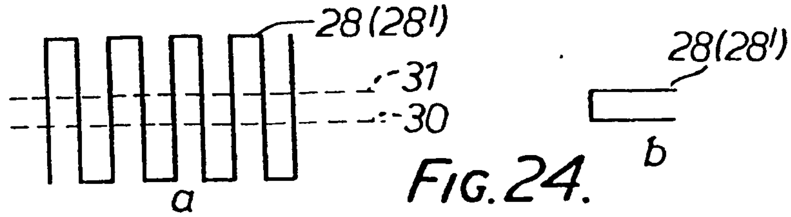


FIG. 24.

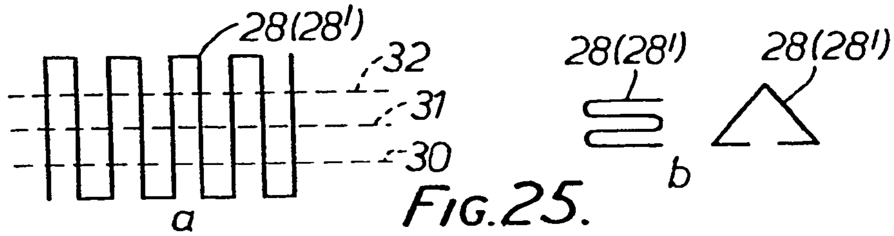


FIG. 25.

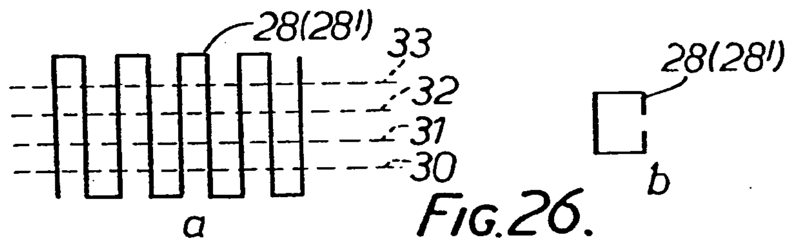


FIG. 26.

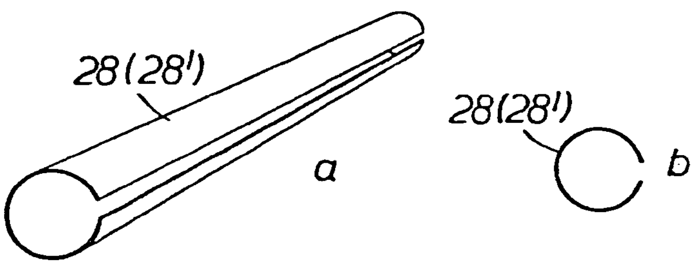


FIG. 27.

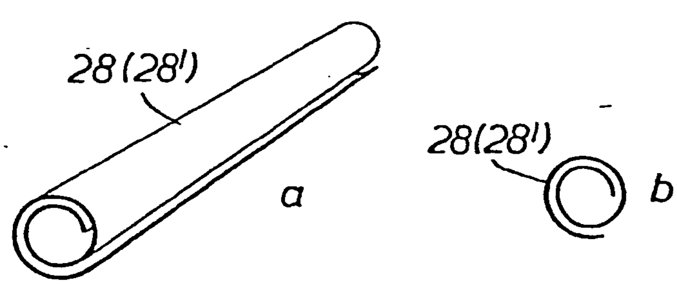


FIG. 28.

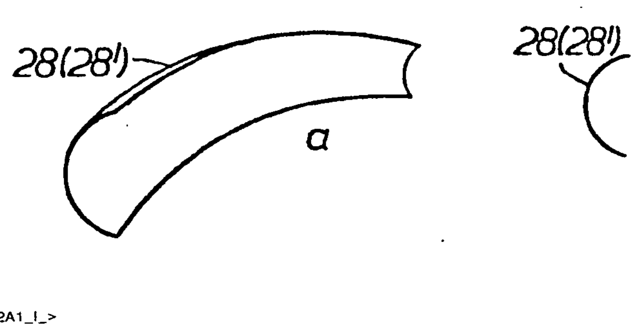


FIG. 29.

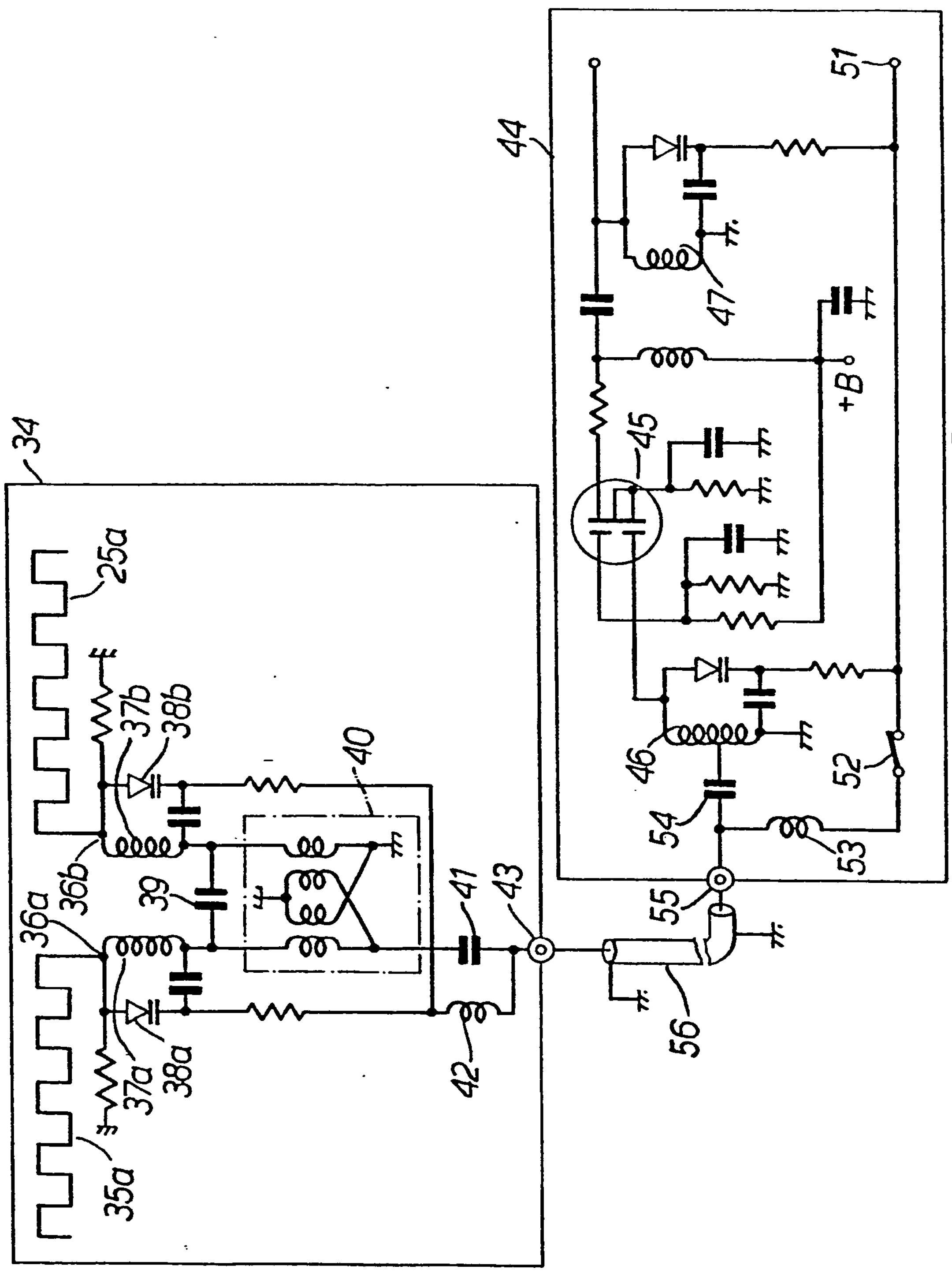

34
25a
35a
36a
36b
37a
37b
38a
38b
39
40
41
42
43
44
45
46
47
51
52
53
54
55
56
+B

FIG. 30.

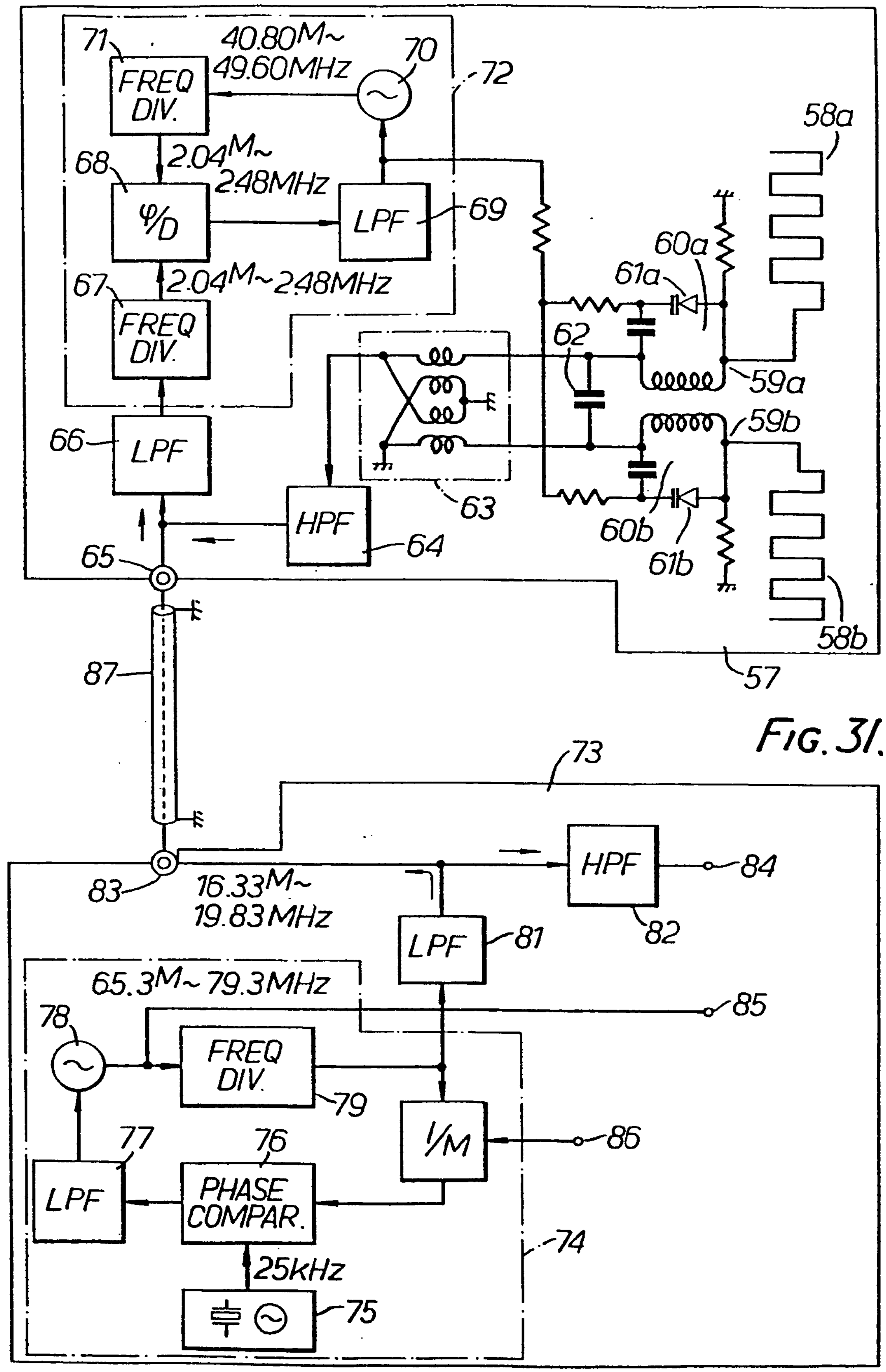

71
FREQ DIV.
40.80M~ 49.60MHz
70
72
68
2.04M~ 2.48MHz
φ/D
LPF
69
67
2.04M~2.48MHz
FREQ DIV.
66
LPF
HPF
64
65
63
62
58a
60a
61a
59a
59b
60b
61b
58b
57
87
73
83
16.33M~ 19.83MHz
HPF
84
82
LPF
81
65.3M~79.3MHz
85
78
FREQ DIV.
79
1/M
86
77
76
LPF
PHASE COMPAR.
25kHz
75
74

FIG. 31.

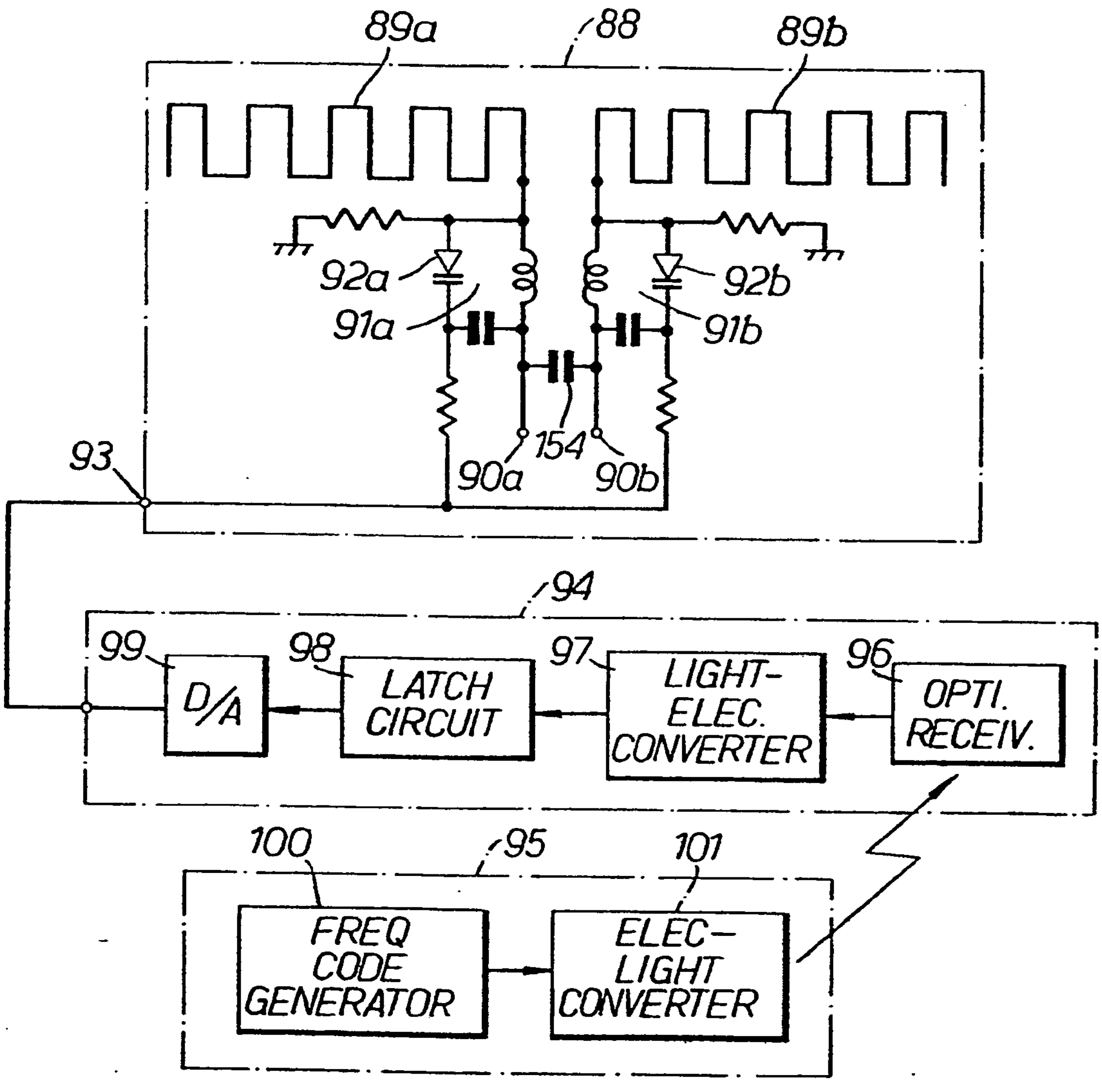

89a
88
89b
92a
92b
91a
91b
154
90a
90b
93
94
99
D/A
98
LATCH CIRCUIT
97
LIGHT-ELEC. CONVERTER
96
OPTI. RECEIV.
100
95
101
FREQ CODE GENERATOR
ELEC-LIGHT CONVERTER

FIG. 32.

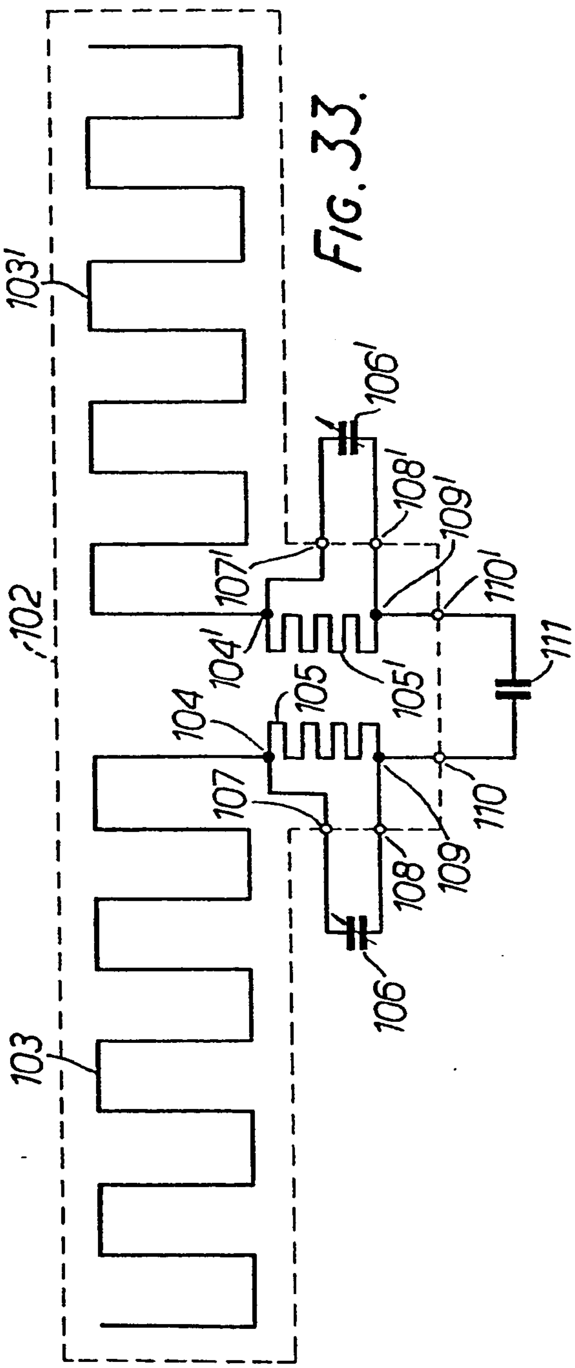

102
103
103'
104
104'
105
105'
106
106'
107
107'
108
108'
109
109'
110
110'
111

FIG. 33.

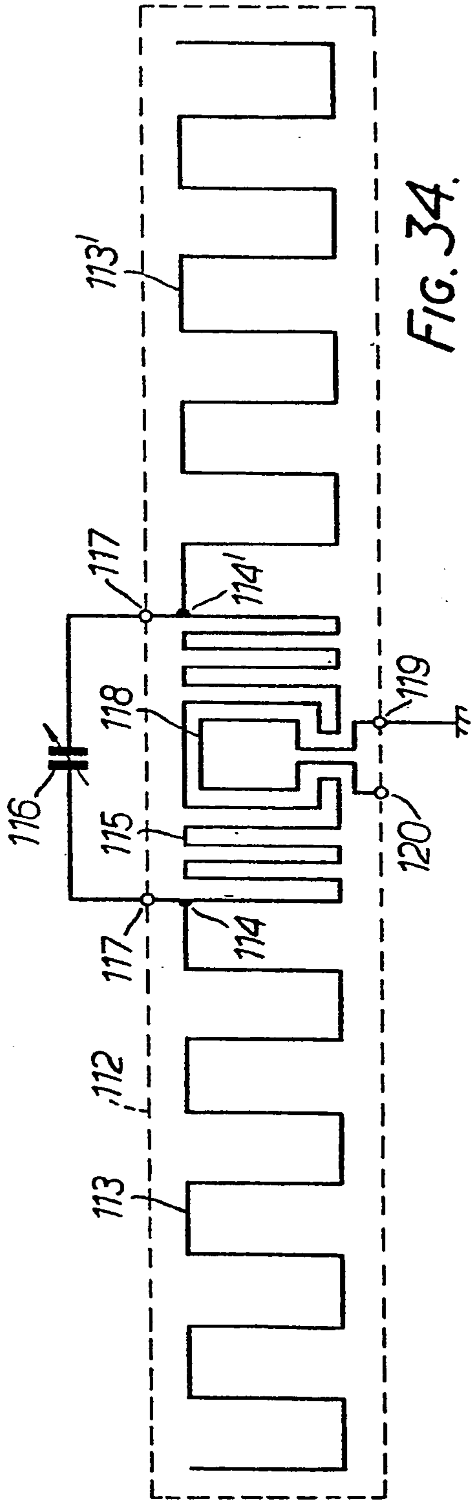
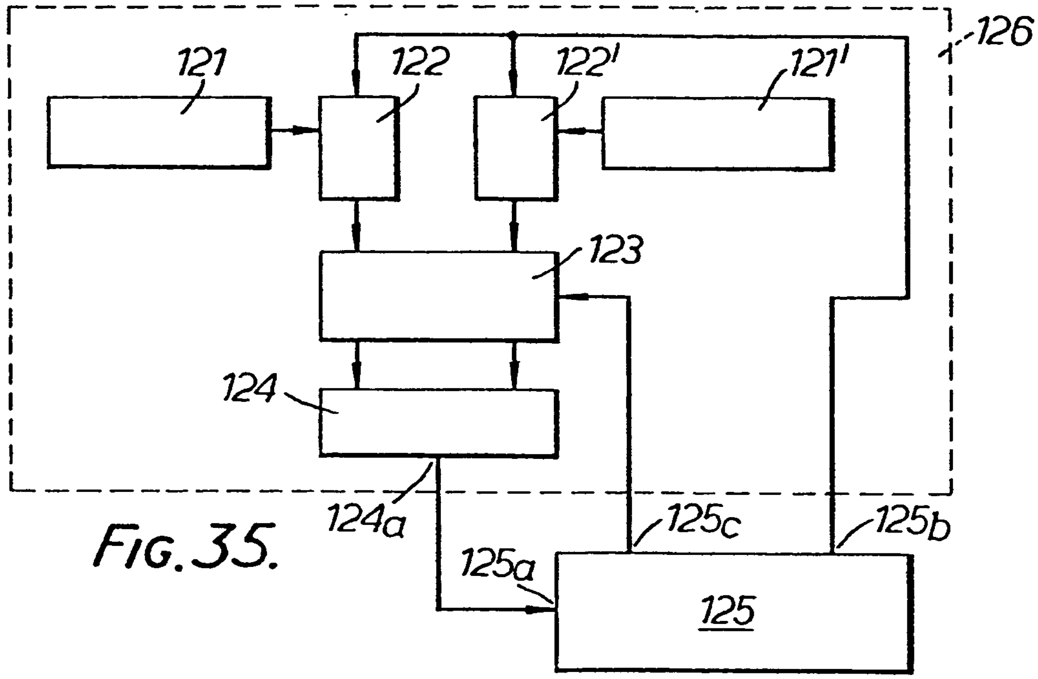
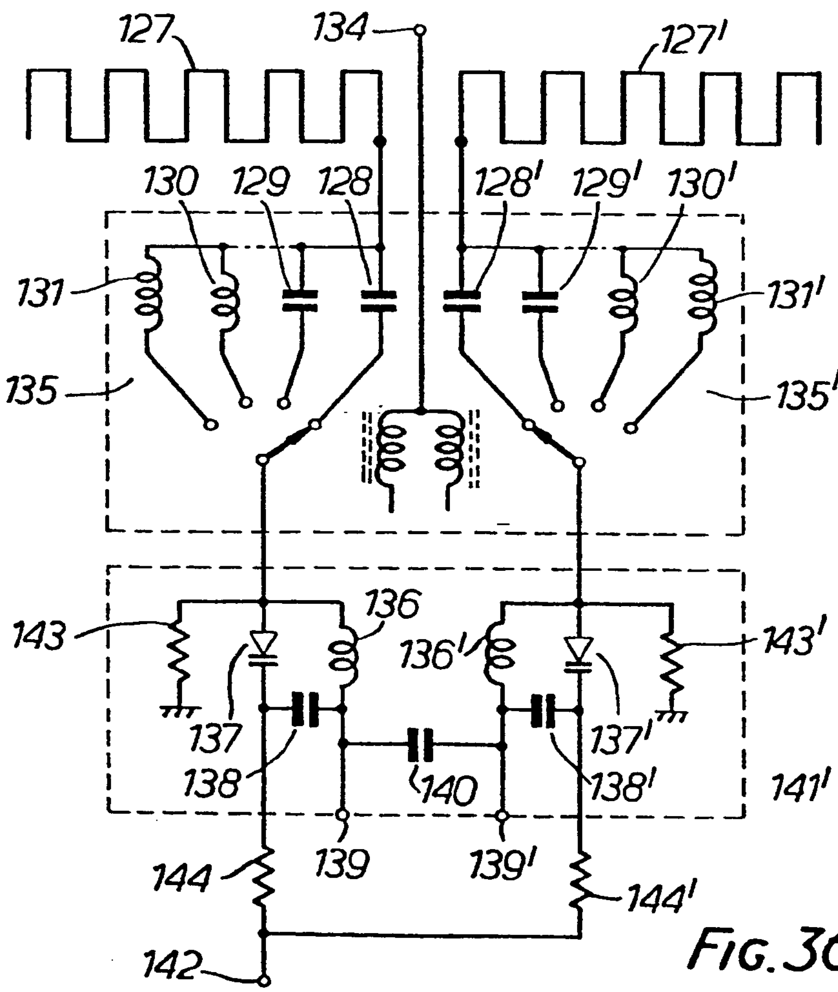

112
113
113'
114
114'
115
116
117
118
119
120

FIG. 34.



126
121
122
122'
121'
123
124
124a
125c
125b
125a
125

FIG. 35.



127
134
127'
130
129
128
128'
129'
130'
131
131'
135
135'
143
136
136'
143'
137
137'
138
140
138'
141'
144
139
139'
144'
142

FIG. 36.

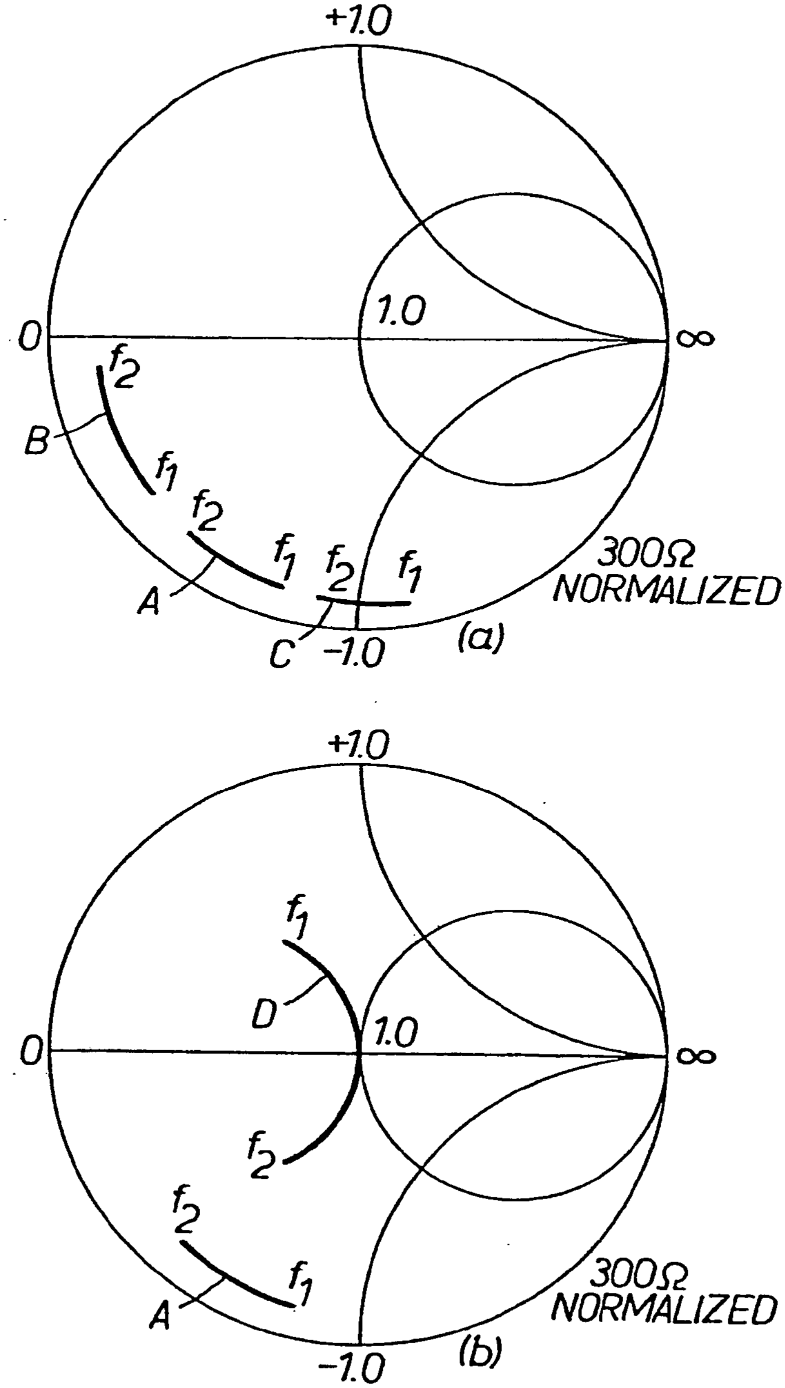

+1.0
1.0
0
∞
f_2
B
f_1
f_2
f_1
f_2
f_1
A
C
-1.0
300Ω
NORMALIZED
(a)
+1.0
f_1
D
1.0
0
∞
f_2
f_2
f_1
A
300Ω
NORMALIZED
(b)
-1.0

FIG. 37.

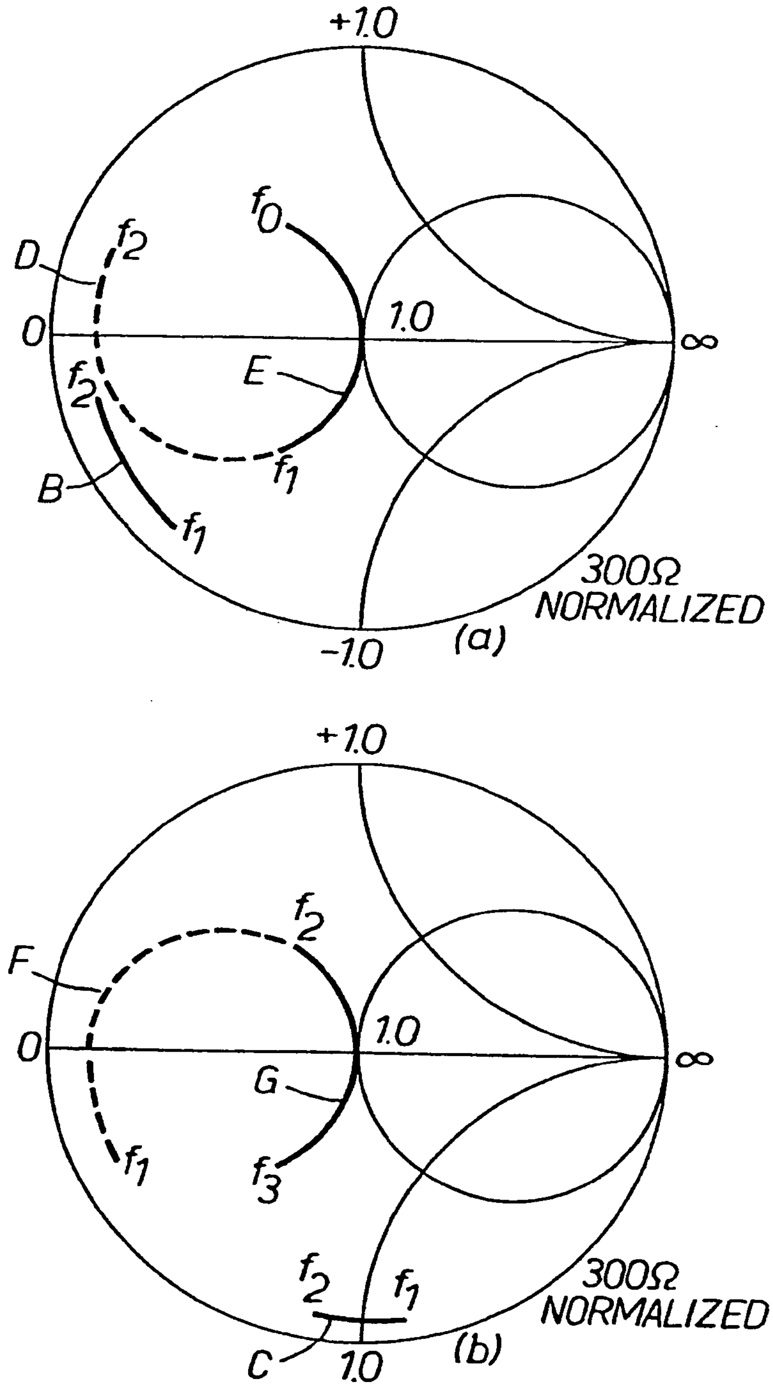

+1.0
f_0
D
f_2
0
1.0
∞
E
f_2
f_1
B
f_1
300Ω
NORMALIZED
(a)
-1.0
+1.0
f_2
F
0
1.0
∞
G
f_1
f_3
f_2
f_1
300Ω
NORMALIZED
C
1.0
(b)

FIG. 38.

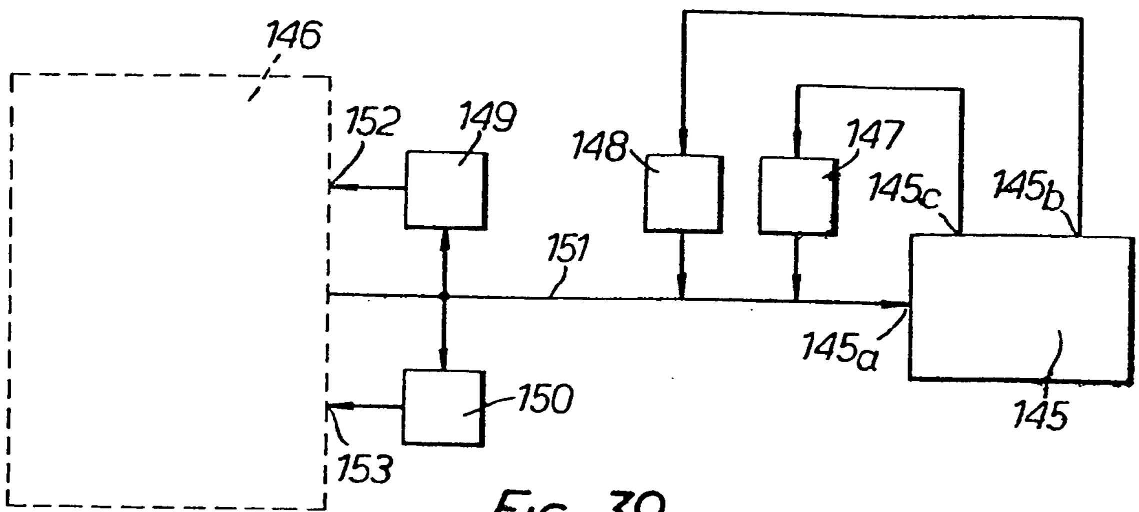

146
152
149
148
147
145c
145b
151
145a
145
150
153

FIG. 39.

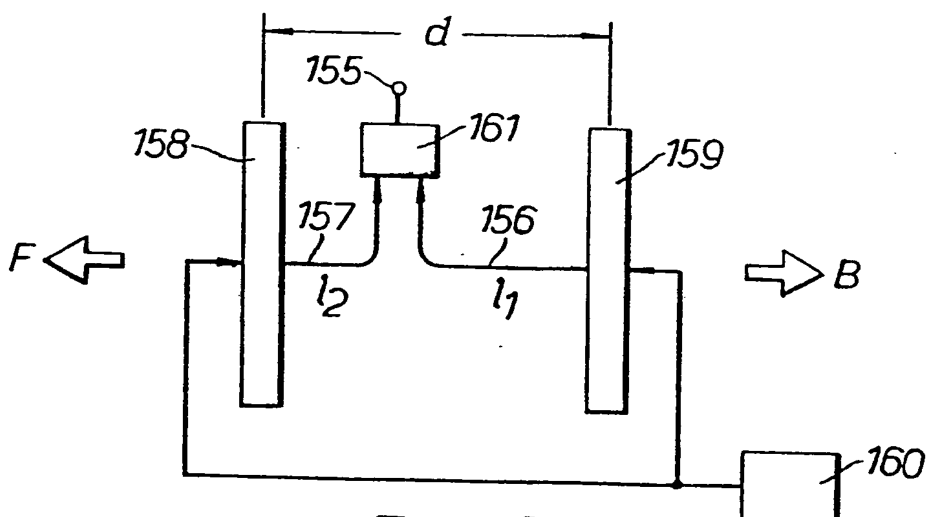

d
155
161
158
159
157
156
F
B
l_2
l_1
160

FIG. 40.

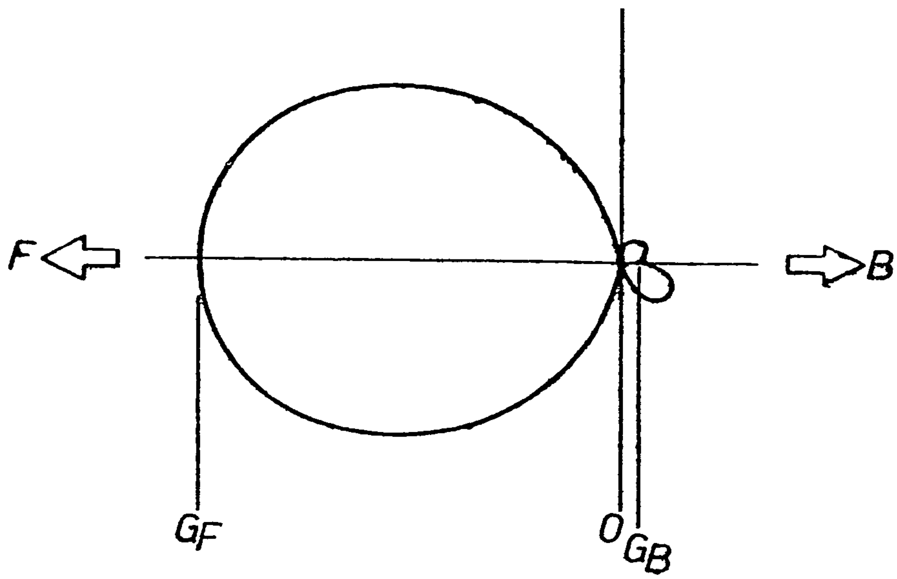


FIG. 41.

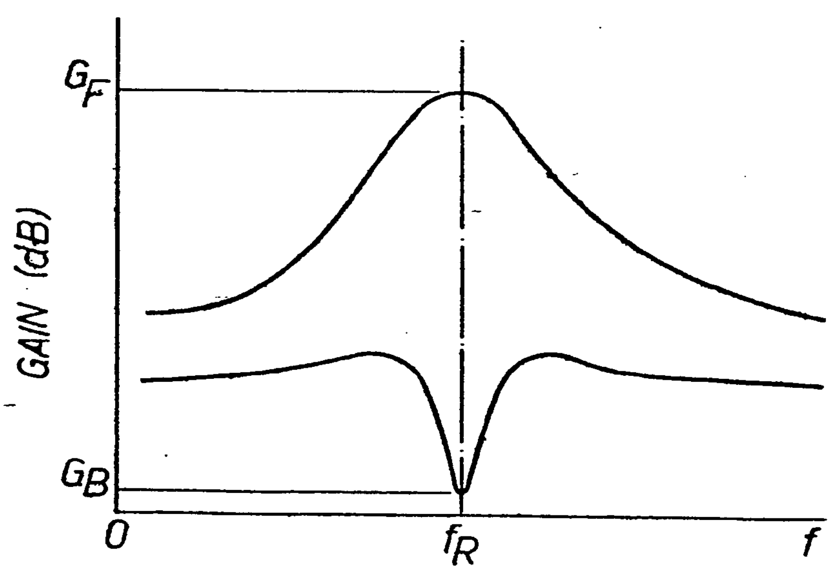


FIG. 42.

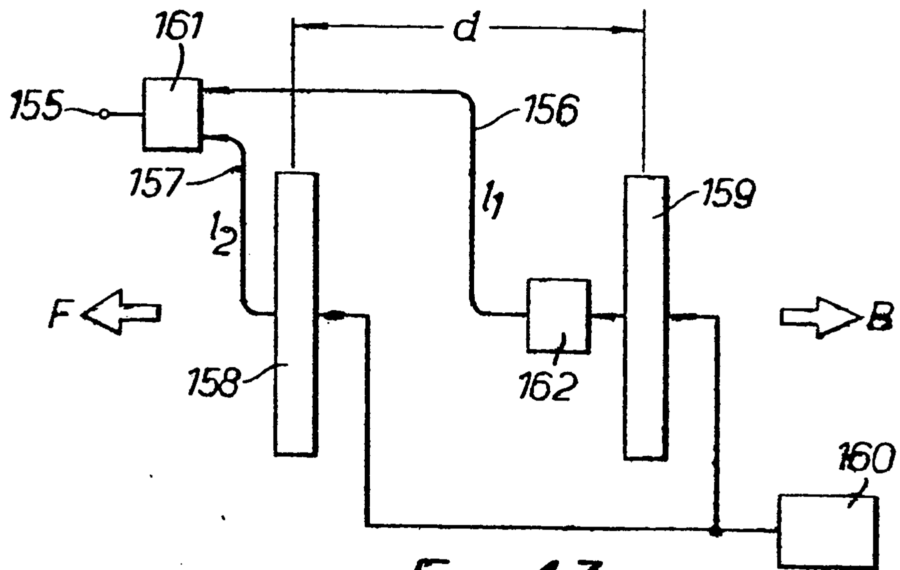


FIG. 43.

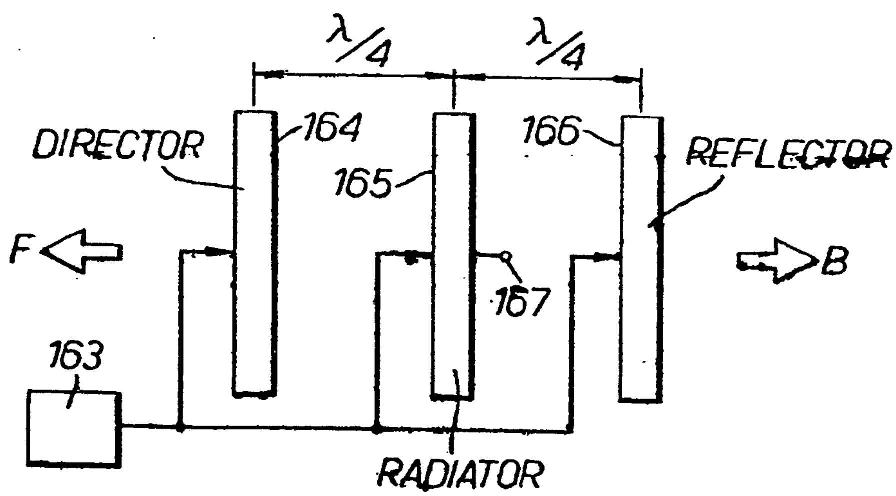


FIG. 43(a).

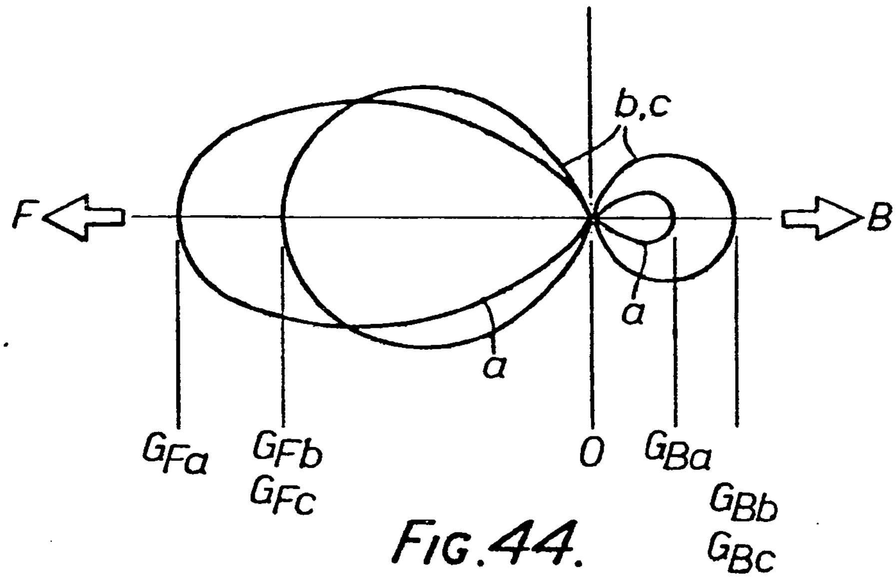

F
B
b,c
a
a
G_{Fa}
G_{Fb}
G_{Fc}
0
G_{Ba}
G_{Bb}
G_{Bc}

FIG. 44.

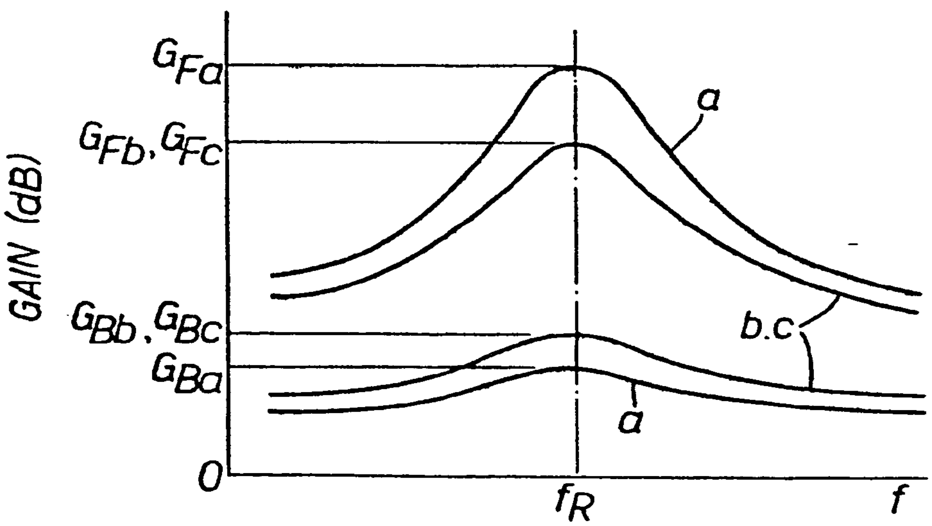

GAIN (dB)
G_{Fa}
G_{Fb}, G_{Fc}
G_{Bb}, G_{Bc}
G_{Ba}
0
a
b.c
a
f_R
f

FIG. 45.

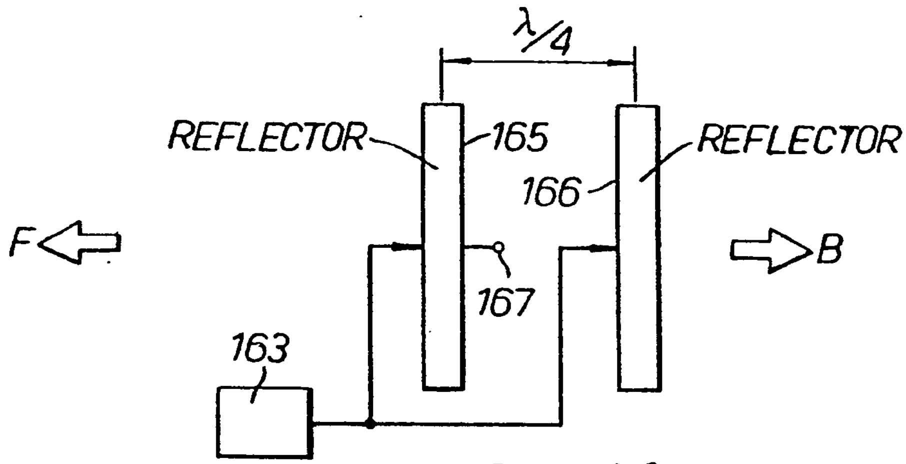

λ/4
REFLECTOR
165
REFLECTOR
166
F
B
167
163

FIG. 46.

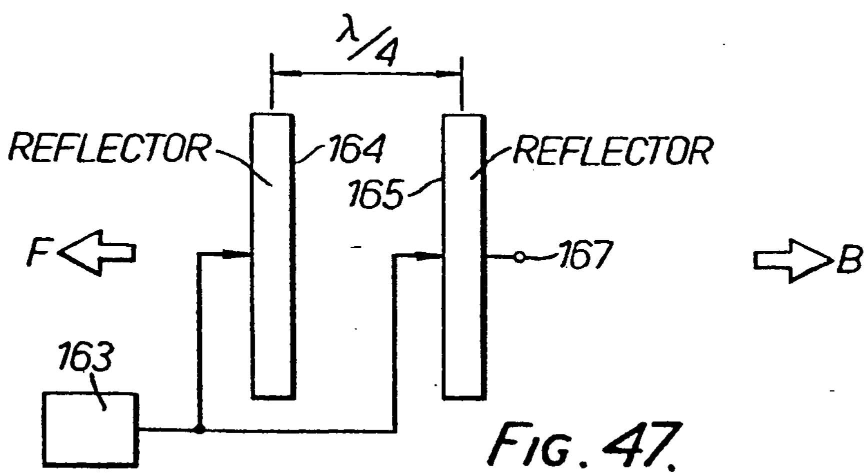

λ/4
REFLECTOR
164
REFLECTOR
165
F
167
B
163

FIG. 47.

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 80 30 2020.5

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	DE - A1 - 2 456 206 (PHILIPS) * fig. *	1	H 04 B 1/18 H 01 Q 23/00 H 03 J 3/24 H 03 J 9/06
	--		
	DE - B - 1 616 278 (INT. STANDARD ELECTRIC CORP.) * fig. 1 to 16 *	3	
	--		
	DE - A1 - 2 826 474 (TEXAS INSTRUMENTS) * fig. 1 and 2 *	4	
	--		TECHNICAL FIELDS SEARCHED (Int.Cl.3)
	DE - A1 - 2 606 271 (SECRETARY OF STATE FOR DEFENCE OF THE UNITED KINGDOM) * fig. 8 *	7	H 01 Q 23/00 H 03 J 3/00 H 03 J 9/00 H 04 B 1/18
	--		
	DE - B - 2 023 906 (MOTOROLA) * fig. 1 to 4 *	2	
	--		
P	DE - A1 - 2 821 202 (J. KECK) * fig. *		
	--		CATEGORY OF CITED DOCUMENTS
A	DE - A1 - 2 816 786 (FUJITSU TEN LTD.) * fig. 1 to 14 *		X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons
	--		
A	DE - A - 1 766 720 (H.H. MEINKE et al.) * fig. 1 to 10 *		
	--		
A	US - A - 4 038 662 (E.M. TURNER) * fig. 1 to 3 *		
	-- ./..		
X	The present search report has been drawn up for all claims		&: member of the same patent family, corresponding document

Place of search	Date of completion of the search	Examiner
Berlin	12-09-1980	BREUSING

0021762

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 80 30 2020.5

- page 2 -

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.3)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
A	US - A - 4 021 810 (S.I. URPO et al.) * fig. 1 to 7 * ----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.3)

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